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SUBSURFACE STUDY OF GLACIAL DEPOSITS AT CLEVELAND, OHIO

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The soil[1] strata underlying the City of Cleveland, Ohio, have been laid down largely through glacial action in a complex fashion. A correlation and mapping of the strata throughout this area would be very helpful to geologic studies and engineering projects. The undertaking of a correlation of this locality is difficult because of the irregularity and complexity of glacial action, and more so because of the fact that exposures of glacial drift are to a large extent concealed by a thick

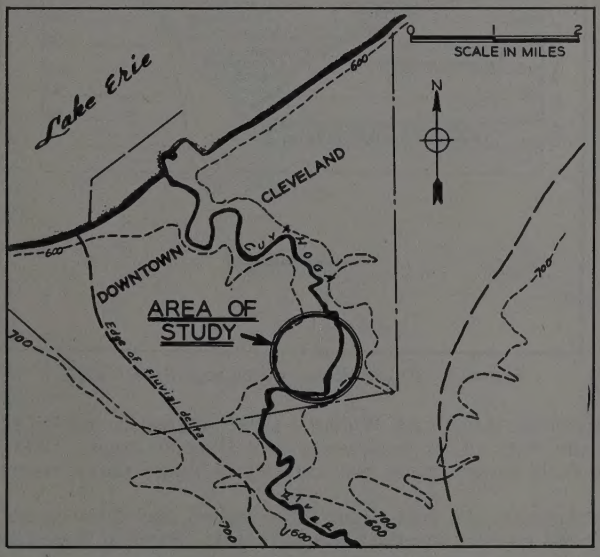

FIGURE 1. The Cleveland Region.

blanket of alluvium deposited during the high-level stages of the post-glacial lakes. Dependence must be had to greatest extent upon the information given by soil borings.

This paper outlines such a study for a relatively small area within the narrow valley of the present Cuyahoga River, approximately 3 miles south of Lake Erie.

[1]In this study the term "soil" is used in the sense commonly accepted by engineers engaged in foundation and soil mechanics studies. It means essentially unconsolidated material overlying bedrock.

From a number of soil borings in the area, continuous till sheets alternating with lacustrine clay beds are identified, and a picture of the drift sequence is obtained. Extrapolation of soil information from this area to other parts of Cleveland would be unwise until more boring data are available, because of probable rapid lateral change. But within the area studied (fig. 1) several continuous soil strata can be relied upon to large degree.

RECENT GEOLOGIC HISTORY OF THE CLEVELAND AREA

During the Tertiary period the streams of the Cleveland area developed deep, relatively narrow valleys in their northward courses into what is now Lake Erie. Then, during the Pleistocene epoch, ice sheets advanced southward into the area, dammed the streams, reduced the hills, and left the valleys largely filled with deposits of till. Of the major stages of glaciation, the last that covered this area

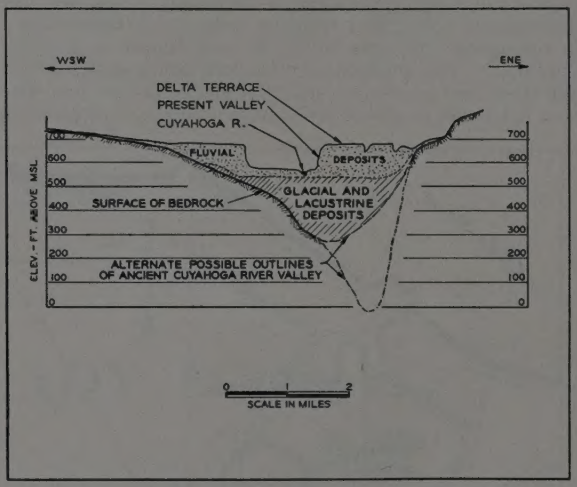

FIGURE 2. Cross Section of Cuyahoga River Valley.

was the Wisconsin stage. As Williams (1940) states, it has to a great degree obliterated the work of its predecessor, the Illinoian stage. The advance and recession of each major glacier was marked by many minor reversals with the seasons.

A series of glacial and post-glacial lakes existed during and after the recession of the Wisconsin glacier from the Cleveland area. Some of these lake stages were much higher than present Lake Erie. One or two were probably 15 to 30 feet lower.

TOPOGRAPHY

The general topography of Cleveland is indicated by figure 1. A delta plain, established during the time of the high-level glacial lakes, fills the pre-glacial Cuyahoga River valley to an elevation of 660 to 680 feet above sea level. Much of downtown Cleveland is built upon this delta. The present Cuyahoga River has cut its valley some 90 feet lower, and now flows at the level of present Lake Erie (573 feet above sea level) through a flood-plain ½ to 1 mile wide.

Within 5 to 8 miles of Lake Erie, the present river valley lies generally west of a pre-glacial river valley (U. S. Geol. Bull. No. 818, 1931). Bedrock slopes steeply down to the east in the area where the borings under study were made, which agrees with reports that the pre-glacial valley is very deep (fig. 2).

GLACIAL AND STREAM ACTION IN THE CUYAHOGA VALLEY

During the period of glacial advance, the Cuyahoga River valley was undoubtedly widened, and the deepest portions of the valley filled with glacial out-

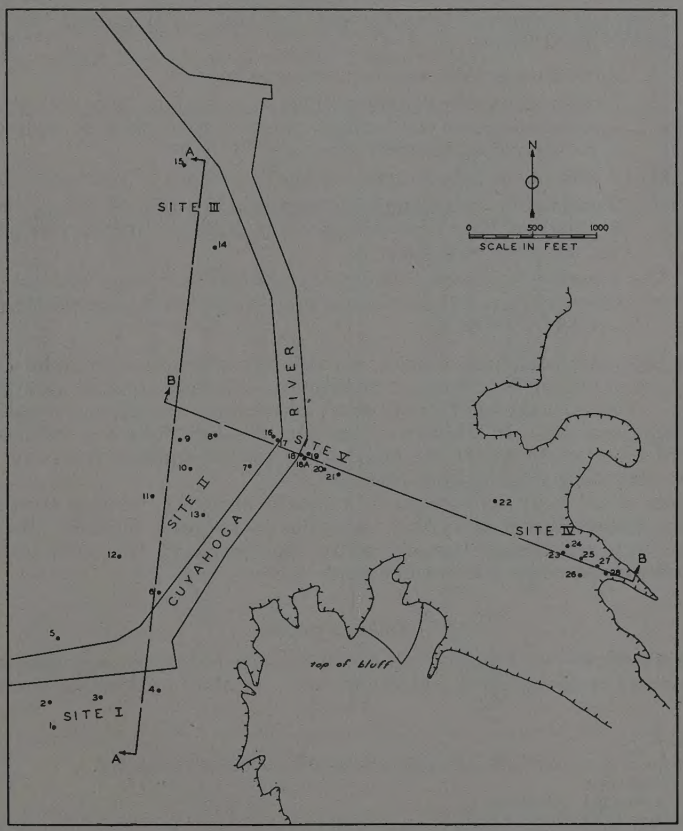

FIGURE 3. Location of Borings.

wash and till. When the glacier front was at or near Cleveland, water was ponded to the south. During the Wisconsin stage the ice sheet covered and uncovered this area a number of times. With each advance a layer of till was deposited, usually a stiff, unstratified, stony clay. Following each recession, a blanket of stratified sand, silt and clay was laid down over the till in the waters of the ponded lake. After the final departure of the ice sheet northward, alluvium, largely sand, was brought down the valley by the river and laid over the deposits of till and lacustrine material. Deltas of various heights were formed and eroded away with

the changes in level of the post-glacial lakes. When the lake levels dropped the Cuyahoga River began to carve its new valley. While Lake Erie was at its lowest level, it is probable that the river cut its narrow valley deeper than it is at present, re-sorting some of the material found somewhat below present lake level. The unusual stiffness of topmost layers of clay in some of the bore holes is interpreted as the result of dessication of lacustrine clay during a lake stage lower than the present.

SOIL BORINGS AND LABORATORY TESTS

Data from soil borings at five sites were available for this study, as shown in figure 3, and as listed below.

Site I: 4 continuous tube sample borings to bedrock.

Site II: 5 continuous tube sample borings to a depth of 60 to 150 feet.
7 standard Gow-type borings, most of which went to bedrock, with a jar sample taken every 5 feet.

Site III: 2 continuous tube sample borings to a depth of 150 feet.

Site IV: 2 continuous tube sample borings to a depth of 50 feet.
5 standard Gow-type borings to a depth of 100 to 150 feet, with jar samples every 5 feet.

Site V: 4 borings to bedrock and 3 borings 220 feet deep, with jar samples every 10 feet, and continuous tube samples from one hole from depth 170 feet to bedrock.

From the continuous tube samples, unconfined compressive strengths and water contents were obtained. Physical descriptions of most of the samples were available. These list the type of soil, color, approximate consistency, stratification if any, inclusions, etc. In addition to the data obtained from the soil boring and laboratory reports, the writer examined some 150 jar samples from Site V, and ran such laboratory tests as were pertinent.

Samples of till from the borings are typically stiff clay, without stratification, and often contain stones and other inclusions in irregular manner. Samples of lacustrine clay deposits are usually softer than adjacent tills, and often show clear horizontal partings of silt or fine sand.

CORRELATIONS

Figure 4 shows the types of soil found in each bore hole, and apparent correlation from boring to boring and site to site. Symbols used on the figure are as follows:

Soil Types—

F = fluviatile—sand, gravel, river silt; also includes man-made fill.
L = lacustrine.
L_s = lacustrine, stratified.
L_u = lacustrine, unstratified.
T = till—unsorted material.
T_w = till, waterlaid, usually having some sorted characteristics.
O = glacial outwash.

Soil Strata—

A = fluvio-delta deposit and river-laid material.
B = generally soft lacustrine clays.
B_1 = till, soft to very stiff.
C = till, medium to stiff.
D = lacustrine clay, soft to medium.
E = stony clay till, stiff to extremely stiff.
F = lacustrine silty clay, medium to stiff.
G = hard stony clay till, and outwash of sand and gravel.

Figure 5 is a generalized recapitulation of the information of figure 4, drawn to horizontal as well as vertical scale.

It is to be noted that 4 layers, B. C. D. and E, are continuous through all the sites. Layers below E are interrupted only by the rise of the bedrock across their levels.

Layer A is also continuous as a general, fluvial deposit, but the typical grey sand of the post-glacial delta deposit, which in the present river valley has been eroded to a relatively thin layer 10 to 20 feet in thickness, is found in some drill holes to be entirely removed and replaced by a flood-plain river deposit of stony silt, peat, etc.

Till layer B_1 intrudes between layers A and B on the east (Section B-B). This till layer is absent from the area of Sites I, II, and III.

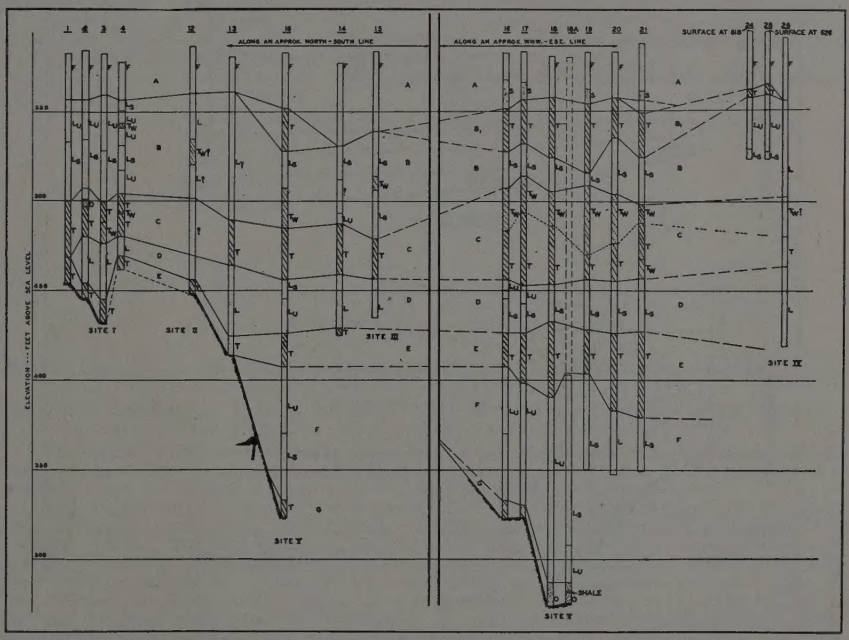

FIGURE 4. Borings and Soil Strata.

The general sequence is that of a basal till, Layer G, (which in some borings may be weathered shale or a mixture of weathered shale and till), overlain by alternating lacustrine clay and till units. The lowest till layer, G, is interpreted as Illinoian. The three overlying till sheets, E, C, and B_1 are interpreted as deposited by three advances of the Wisconsin ice. Layer E, which is more compact than the till of the two overlying sheets may be Tazewell, and the two upper sheets may be early Cary and late Cary, respectively. This postulated Wisconsin sequence correlates with that recently determined by White (1950) for Wisconsin till deposits at the surface south of Cleveland, in Summit, Medina, Portage, and adjacent counties. Still farther south, Illinoian till exists at the surface beyond Wisconsin drift (White, 1942).

Pockets of stratified material occur in the till sheets at various points. These are "water-laid till," released from the ice into ponds or streams beneath the glacier, and sorted before final deposition. Other instances of water-laid till are isolated bands of sorted or unsorted till, surrounded on all sides by typical lacustrine deposits. In such case, samples may show definite stratification, yet have pebbles and sand particles scattered through the bands of clay. This is also typical of water-laid till, indicating the dropping of the till intermittently into a ponded area from an overlying ice sheet or from floating ice cakes. In short, glacial deposits do not adhere strictly to the three common classes ascribed to them: till, outwash, and lacustrine deposits; but may vary through a range of combinations.

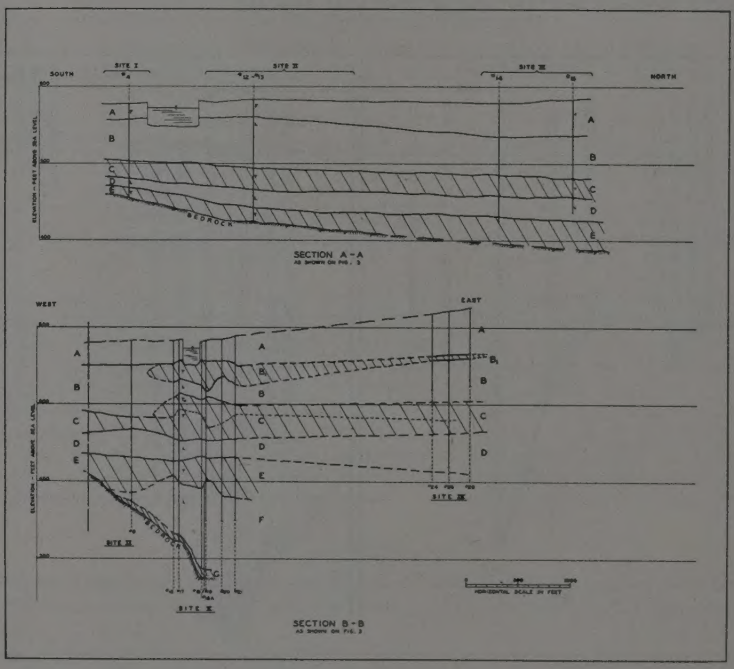

FIGURE 5. Generalized Soil Strata.

Top and bottom borders of each till sheet are irregular by their very nature, and also from the erosion of melt-water streams laced through and under the ice. In spite of the irregularities of glacial deposits, the continuous layers indicated in figures 4 and 5 seem well substantiated by the borings.

All layers of clay beneath Layer A have been precompressed by the load of the delta material, which extended up to elevation 680 at the end of the Glacial Lake Warren stage. Earlier, the delta was probably at an elevation between 760 and 800, the levels of Glacial Lake Maumee. Thus, as noted by Peck (1948), without regard for the weight of the ice sheet which acted upon some of the clay layers, these have all been subjected to precompression on the order of the weight of from 100 to 200 feet of sand, perhaps 5 to 10 tons per square foot.

Location of bedrock eastward from the river is not indicated by the borings available in this study. It may continue at a steep slope downward into the sea level gorge indicated by some of the old gas well reports (U. S. Geol. Surv. Bull. No. 661, 1917), or it may conform to a more characteristic valley cross section for shale. In the latter case, the level of the bedrock found in the Site V borings may represent very nearly the lowest points of the preglacial valley.

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Laboratory Exercises in General Biology. *James Watt Mavor.* The Macmillan Company, New York. Fourth Edition, 1952. v+333 pp. $3.50.

The fourth edition of Dr. Mavor's General Biology follows the plan of previous editions more or less closely. However, considerable improvement has been made by the addition of a number of new well-designed illustrations and by the rewriting of some chapters.

The subject matter is arranged in six parts. Part One introduces the student to biological science, methods for its study, characteristics of living things and a classification of plants and animals. In Part Two representative plant forms are presented in evolutionary sequence, with considerable attention being paid to the morphology of the angiosperms. Parts Three and Four present representative forms of the animal kingdom. The anatomy and physiology of frog and man are dealt with in detail. Part Five includes the development of the individual and the principles of inheritance. Throughout the book evidences of progressive complexity of development are offered naturally and in an orderly fashion, and in Part Six these evidences are brought together in a presentation of the history and theories of evolution.

Chapter twenty-three has caused some confusion in the minds of beginning students. This chapter contains a review of animal phyla previously studied and a brief survey of some additional phyla. The sequence of simpler to more complex forms is not maintained and detracts from the otherwise orderly procedure.

The three appendices of the text are valuable. The second provides reference material in chemistry for those students having an inadequate background in chemistry. The first, a Synoptic Table of the Plant and Animal Kingdoms, is very useful as is also the third, a Glossary of Technical Terms.

The manual accompanying the text is arranged for close coordination with the text. It is so designed that it may be used in its entirety or individual exercises may be selected by the instructor to meet the particular needs of various plans of study. Part One of the manual is concerned with instructions and contains seven excellent plates as well as adequate directions and explanations for laboratory procedure. Part Two provides well prepared work sheets.

Used together the text and the laboratory exercises should provide the beginning student with a sound background in biological studies.

L. Eloise Whitwer

SHORT TIME VARIATION OF TEMPERATURE IN LAKE MENDOTA, WISCONSIN[1]

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The bathythermograph can be adapted for use on small lakes. Lake Mendota's thermal differences were completely checked with 90 soundings in six hours. The variations found are much the same as those of other great lakes.

During the summer of 1949 over 500 soundings were made with a bathythermograph and more than 50 soundings were made with a Whitney electrical thermometer. The bathythermograph was by far the most advantageous instrument for the study, for it was possible to cover a large area within a short period of time. The Whitney thermometer had the property of being able to check the temperature of any desired depth for any length of time.

Table 1 shows the data pertinent to the cruises made. The wind and air temperature data were recorded from a station near the edge of the lake.

TABLE 1

Date	Time	Soundings	mph Wind	Wind mph Previous 24 hours
10 August 1949	1100–1500	90	SW 15	WSW 7
16 August 1949	0900–1700	100	E 12	E 10
19 August 1949	0930–1530	40	NE 13	NE 10–18
23 August 1949	0900–1500	90	S 13	W 6

CRUISES

On August 10, there was a surface variation of 4° F. with definite pockets of warm and less warm water (fig. 1). The warm water was on the east and northeast side of the lake, the wind from the southwest piled the warm water on the downwind side of the lake. Off the many points of land were tongues of homogeneous water jutting into the lake, they appear to be regions of very little current movement. The isotherms move out in bands toward the northeast, although pockets of cold water can be found on the downwind side of the lake.

Figure 2 shows the 20-foot level for the 10th of August. The tongues of water off points of land are still apparent in a few regions. This surface had a 7° F variation with the warm water still on the downwind side of the lake. In comparing the two figures, the thermal gradient on the southwest side of the lake was 2.5° F/20 feet and on the northeast side or downwind it was 0.5° F/20 feet. In some regions the temperature did not change.

In the large bay the tongues of water curved cyclonically around each other; this was probably an eddy as the bays appear to be a separate circulation from the main part of the lake. This pattern was shown in Lake Erie by Parmenter (1929). The tongues of water off points of land was also shown by Parmenter, although he did not describe it.

[1]Paper presented to the American Society of Limnology and Oceanography, December, 1949.

By August 16, 1949, there was a complete change from the surface conditions of the 10th (fig. 3). The reversal of the thermal distribution was due to a steady east wind. The water had cooled slightly, but the variation still exceeded three degrees. Tongues of water off the points of land were still apparent.

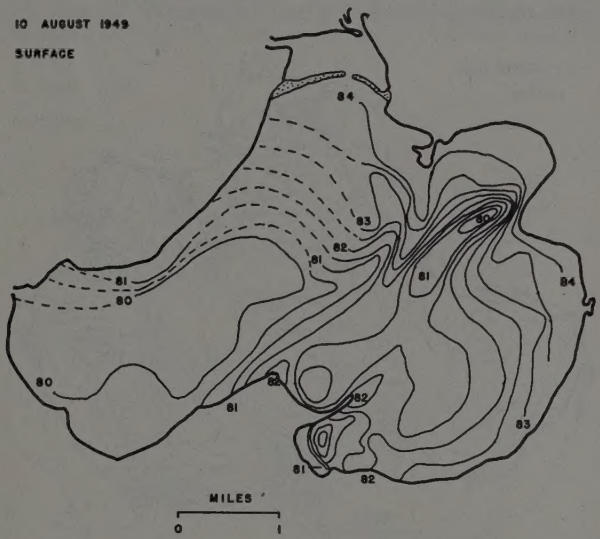

FIGURE 1. August 10, 1949. Isotherms are in degrees F. Surface.

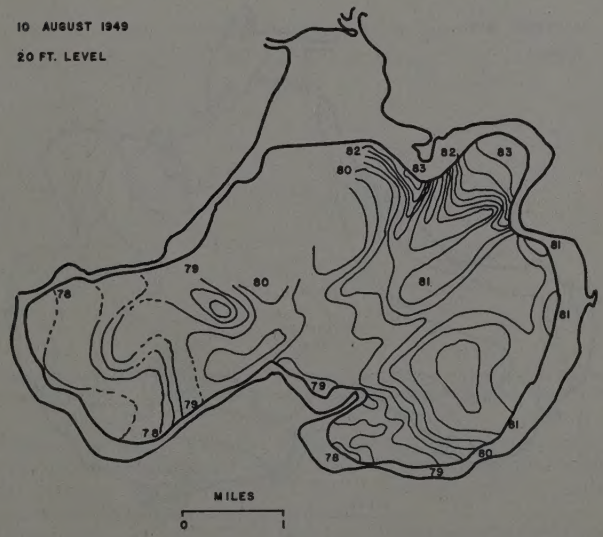

FIGURE 2. August 10, 1949. Isotherms are in degrees F. 20 foot level.

On August 19, the wind was from the northeast and there was considerable mixing within the epilimnion (fig. 4). The range of temperature was small but there was a steady increase of temperature from east to west, the warmer water being on the downwind side of the lake. The air was colder than the water and there was a good coupling between the wind and water.

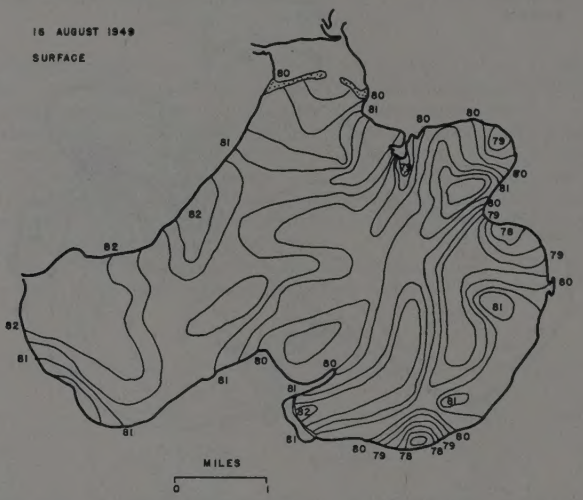

FIGURE 3. August 16, 1949. Isotherms are in degrees F. Surface.

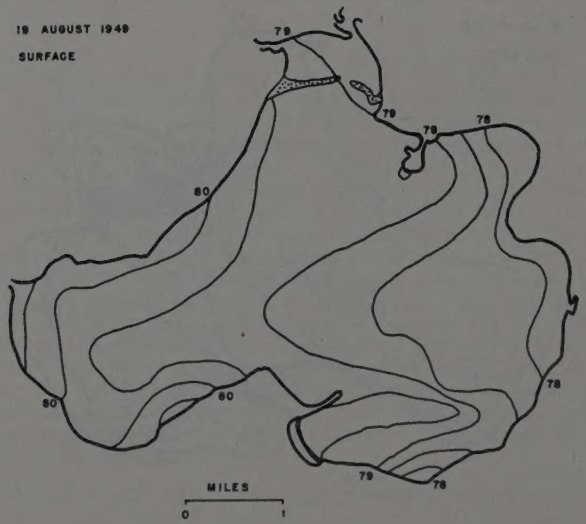

FIGURE 4. August 19, 1949. Isotherms are in degrees F. Surface.

On August 23rd, the horizontal variation of temperature on the surface is three degrees F (fig. 5). There had not been a complete change in the thermal condition of the lake from the previous day's west wind to the south wind of the 23rd. The points of land again showed tongues of water of uniform temperature. This map also brings out the shelter belt effect of a point of land, which breaks or slows down the wind, leaving the water in the lee of the land little disturbed.

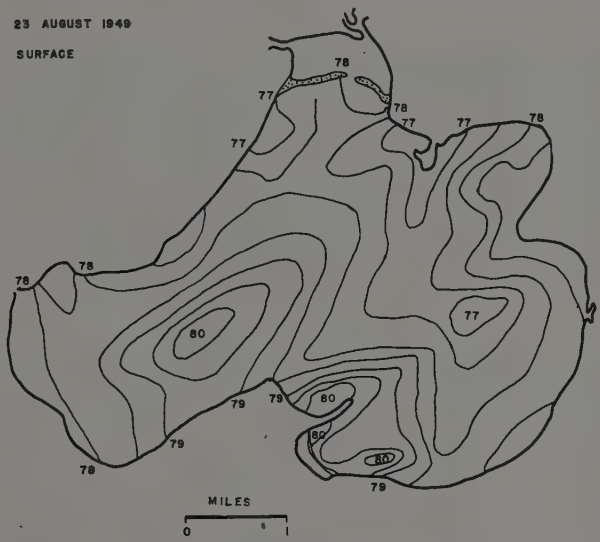

FIGURE 5. August 23, 1949. Isotherms are in degrees F. Surface.

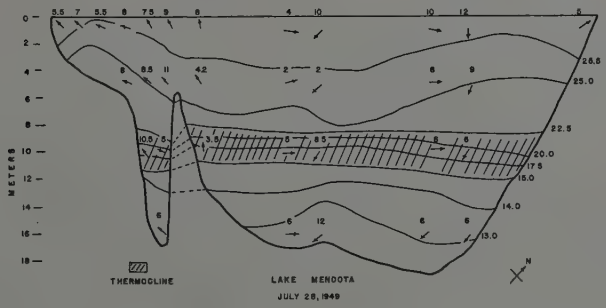

FIGURE 6. Section across the entrance to the large bay, wind was south-southwest 16.4 mph. Isotherms in degrees C. All numbers after the current arrows are in meters per minute.

When the warm water is piled to considerable depth on one side of the lake it produces pressure-temperature solenoids. This unbalanced condition can and does cause strong currents toward the downwind side of the lake in the hypolimnion, reverse to the surface currents.

Current measurements, using free floating vanes, were made throughout the month of July, and temperature profiles were made with the Whitney thermometer.

Figure 3 shows a striking example of the reversal of deformation in the epilimnion and the hypolimnion. This has been found in several profiles. Note that the fastest currents recorded, 12 meters per minute, were observed at the bottom and at the surface.

Rawson (1950) showed that there was a 4° F change or more in the 7 miles across McLeod bay in Great Slave Lake during August, 1945. These changes compare to those found in Mendota.

SUMMARY

A random sounding is hardly representative of the thermal structure of a lake. The fluctuations of temperature from day to day is not due to heating and cooling alone but mostly, at this season, to the movement of water within the lake. Thermal variations and patterns present in Lake Mendota are also found in other great lakes. An intensive study of the thermal structure of a small lake may give valuable clues to the thermal patterns present in larger lakes.

In an analysis of the four cruises, certain patterns are apparent. (1) The temperature of the lake surface is not horizontally uniform. (2) Deeper layers within the epilimnion show a greater variation of temperature than does the surface. (3) At any given point there is a great short time variation of temperature. (4) The changes can best be accounted for by wind-driven currents within the lake.

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Palomar, The World's Largest Telescope. *Helen Wright.* The Macmillan Company, New York. 1952. 188 pp. $3.75.

Since the initial steps were taken for the construction of the Hale Telescope at Mt. Palomar nearly a quarter of a century ago, this instrument has remained in the minds of young and old as the greatest wonder of the age. Now, when this powerful device for the exploration of the Universe is at work, the public interest is still on the increase. Will it finally settle the question of life on Mars or some other planet still unknown? This seems to remain the leading question. Although the book under review does not entertain such speculations, it does answer clearly and distinctly the many financial, technical, and human problems that were to be faced in the construction of such a great instrument and describes a number of investigations now under way. The story of the building of this giant is told dramatically, accurately, and with a feeling of admiration for all those who shared in this great undertaking of our century. But this is not all. Throughout the narrative there is ever present the great personality of George Ellery Hale, the dreamer, the planner, and the builder. Miss Wright has justly kept her hero ever present during the years of struggles, decisions, and achievements even to the end when the goal was finally in clear view. As Dr. Bowen in the special preface stated, the author has spent several years in collecting material for the official biography of Hale and hence is in a unique position to tell the story of the Palomar Observatory. Indeed, the book is written with imagination and style suitably fitting to the man and the telescope she describes.

The narrative is divided into six main sections, Origin of the Telescope, Birth of the Telescope, Palomar Mountain, A 200-inch Mirror, Telescope and Dome, and Dedication of the Hale Telescope. In these relatively short chapters, the story is told with enough details to give continuity. Even the struggle between the two giant foundations, The Carnegie Institution of Washington and the Rockefeller's General Education Board is not missed.

The book is not meant for the professional astronomer but even the professionals will derive pleasure in reading it. It is well printed and illustrated but it is regrettable that it is so highly priced.

JASON J. NASSAU

BIOLOGICAL AND TAXONOMIC NOTES ON ERYTHRONEURA

(HOMOPTERA, CICADELLIDAE)

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During our investigations of the Cicadellinae of the Corn Belt States, the genus *Erythroneura* has proven to be a real challenge in both a biological and taxonomic sense. Our studies were undertaken with the intent of completing a treatment of the subfamily as a second part of the "Leafhoppers of Illinois." With *Erythroneura* it was realized early that one of the greatest needs was to discover the biologic significance of the species, most of which were then known only from hibernation or vernal collections. After three seasons of host collecting it is obvious that much more information is still needed, but a few generalities about the genus seem worth recording at this time.

HOST RELATIONSHIPS

Species of *Erythroneura* overwinter as adults. In areas of winter or moderate cold, the adults emerge from duff and feed in spring on the first leaves of shrubs or trees, favorites being various species of *Ribes* or *Aesculus*. In Florida the adults are active all year, but during the winter season the species which have deciduous hosts appear to feed on such evergreen shrubs as *Rubus* and *Myrica*.

Later in the spring or early summer, the various species of *Erythroneura* leave their early season food plants and seek out the various definitive hosts on which the eggs are laid and the nymphs develop. These hosts are mostly trees but include a few shrubs, vines, and woody herbs. Within the Obliqua and Maculata Groups a high degree of host specificity is exhibited by each species. Occasionally the host range covers a plant family, as for example certain species which occur on both *Quercus* and *Fagus*. More common are species which occur on several species of one plant genus, as for example several species which seem to occur on any member of the *Quercus alba* group of oaks. Certain species of *Erythroneura*, however, appear to be restricted rigidly to a single member of the host genus. A striking example of this is shown by four or five species of *Erythroneura* which are restricted to *Quercus imbricaria*. Other examples include a pair of species apparently restricted to *Ulmus americana* and *alata*, respectively, and a number restricted to *Cornus florida*.

We have only a small amount of evidence as yet regarding the differences in *Erythroneura* fauna exhibited by the same or related plant species in different parts of their ranges. There is an interesting case with *Alnus:* in northern Michigan it harbors chiefly *nitida* Beamer, in southern Illinois chiefly *rugosae* R. & D., and in northern Illinois we have been able to find no *Erythroneura* at all on it. Similarly the northern and southern faunae of the maples are different, but we have not yet analyzed our data sufficiently to know whether initially observed differences are significant.

TAXONOMIC UNITS

Evidence from many collections on true hosts indicates that, in the main, the species of *Erythroneura* as treated by Beamer, Knull, and other recent authors are sound biologic units. As is the case in many other genera, some species have a relatively small degree of variation, whereas a few exhibit a startling diversity in variational extremes. Possibly the most puzzling example we have encountered

to date is the elm inhabiting *basilaris* complex, which presents some evidence that it is a freely interbreeding group of formerly distinct subspecies or near species.

Another interesting type of circumstance is the occurrence of pairs of seemingly distinct species in which the two species differ in only one observed trait. An example is the *rubroscuta-aesculella* pair which breed on the same host, *Aesculus*. The two species differ only in that the ventral processes of the aedeagus are appressed to the phalicata in *rubroscuta*, but arise well below the phalicata in *aesculella*. It is possible that this difference represents the expression of only one or a few genes, and that merely dimorphism is involved. Yet in other similar cases each species of the pair is on a different host and the two Erythroneuras exist as demonstrably different biologic entities. Hence it seems necessary to regard non-intergrading morphological entities as good species whether this is substantiated by known biologic differences or not.

There still appear with some regularity odd specimens which differ markedly from known forms, and which probably represent distinct species for which we need to search further to establish the host, range, and limits of variation. Descriptions of some of these appear in the following pages.

DESCRIPTIONS OF NEW SPECIES

OBLIQUA GROUP

We are restricting this group to only those species belonging to the closely-knit aggregate containing the species *obliqua* (Say), and characterized by the hook-shaped pygofer hook set off at the base by a distinct suture (fig. 12*D*).

For the species previously considered as the "Western Obliqua Group" we propose the term *Apacha Group*, named for the species *apacha* Beamer, a typical member. In his treatise on this group, Beamer pointed out the complete lack of relationship between these and the true Obliqua Group. As a matter of fact, the Apacha Group is one of the most primitive in the genus and the Obliqua Group one of the most specialized.

Erythroneura juglandacea n. sp.

Both the black dorsal stripe and the aedeagus indicate the close affinity between this species and *atrimucronata* Beamer. From *atrimucronata*, *juglandacea* differs in the longer posterior point of the style and details of the aedeagus.

Length 3 mm. Ground color pale lemon yellow, with a black dorsal stripe extending the entire length of the insect, beginning as a pointed area at the anterior margin of the head and covering all but the sides of the pronotum and elytra back to the cross-veins, beyond which the stripe extends across the entire width of the elytra. Venter with part of mesosternum and most of abdomen black. Male genitalia as in figure 1. Pygofer hook evenly curved. Style with foot oblique to shaft, with sharp heel, minute anterior point, and elongate posterior point which is as long as foot. Aedeagus with large base which is angular ventrad, with no processes, but with a deep and fairly narrow phalicata; this latter is curved dorsad toward apex, and has a pair of sharp, short flanges directed outward and slightly backward.

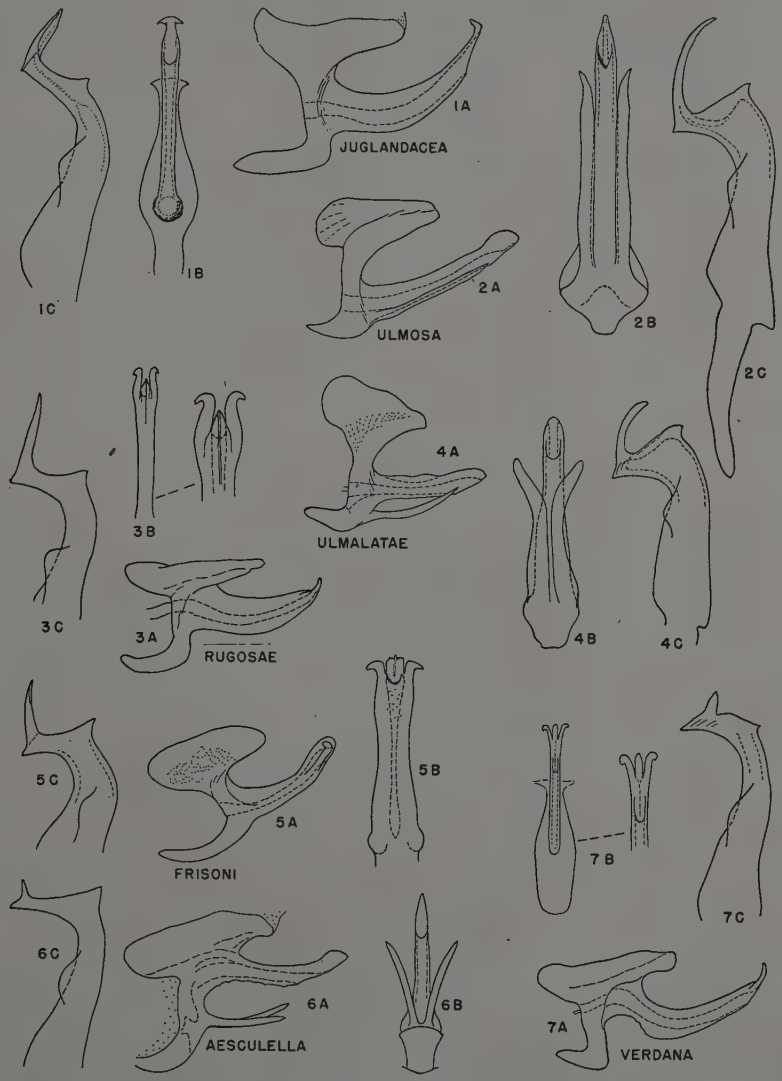
Holotype, male, Horseshoe Lake, Olive Branch, Ill., Aug. 16, 1951, on *Juglans nigra*, Ross & Stannard. Allotype, female, same data. Paratypes, same data, 6♂, 8♀; Hord, Ill., Aug. 31, 1951, on *Juglans nigra*, Ross & Richards, 1♂, 4♀.

Erythroneura ulmosa n. sp.

A close relative of *harpax* Beamer, differing in the longer phalicata and appressed ventral processes of the aedeagus.

Length 3 mm. Color in general coppery green, the head and pronotum lighter, with indications of reddish stripes, the elytra darker, the area beyond the cross-veins very dark, the abdomen entirely dark brown. Male genitalia as in figure 2. Pygofer hook evenly curved. Style with foot angled back slightly upon the shaft, the heel prominent, the anterior point minute, the posterior point very long, curved over the instep and attaining a length greater than the foot.

Aedeagus with phalicata arising at the ventral margin of the socket, with a pair of elongate ventral processes arising beneath it and extending nearly the full length of the phalicata; this latter structure is nearly cylindrical, elongate, and nearly straight, with only a slight dorsal enlargement at extreme apex.



FIGURES 1–7. Male genitalia of *Erythroneura*. *A*, lateral aspect of aedeagus; *B*, ventral aspect of phalicata; *C*, style. Figures 1*A*, 1*B*, 2*B*, 4*B* and 5*B* are 1.5 times the magnification of the others.

In many specimens the dark coppery green on the elytra is poorly developed, in which case the basic red striping characteristic of the group shows clearly through the green and may be the dominant note in the pattern.

Holotype, male, and allotype, female, Shawneetown, Ill., July 14, 1948, on *Ulmus americana*, Mills & Ross. Paratypes, 66♂, 8♀, from Chillicothe, Ohio, and the following localities in Illinois: Anna, Centralia, Dixon Springs, Eichorn, Fairfield, Gibsonia, Karbers Ridge, Kickapoo St. Pk., Louisville, Makanda, Marshall, Monticello, Muncie, Oliver, Paris, Rocky Branch, Shawneetown, Thebes, Urbana, Watseka, Westport, White Heath.

Erythroneura ulmalatae n. sp.

The short aedeagus and curved ventral processes indicate a close affinity between this species and *harpax*, but *ulmalatae* may be distinguished readily by the short posterior point on the style.

Length 3 mm. Color a faded greenish yellow, with faint stripes on the pronotum and head, and with the elytra a darker shade of coppery green. Male genitalia as in figure 4. Pygofer hook evenly curved. Style with foot angled back on the shaft, with a minute anterior point but a long posterior point, nearly as long as foot and curved over the instep. Aedeagus with narrow socket; phalicata of moderate length, slightly curved dorsad, enlarged a trifle at apex, bearing a small dorsal carina at base, and attached near ventral margin of socket; below it arise a pair of long ventral processes which curve slightly upward and outward, and usually are seen curving back over the silhouette of the phalicata.

Holotype, male, Golconda, Ill., July 15, 1948, Mills & Ross, on *Ulmus alata*. Paratypes, same data, 6♂; Ozark, Ill., May 3, 1950. Sanderson & Stannard, 1♂; Karbers Ridge, Ill., Apr. 22, 1935, T. H. Frison, 1♂; Makanda, Ill., Mar. 26, 1935, Ross & Mohr, 1♂.

Erythroneura rugosae n. sp.

This species is most closely related to *jocosa* Beamer and *spatulata* Beamer, differing in the deep phalicata with the apical pair of short, stout, outcurved processes.

Length 2.8 mm. Color a light cream with yellow vittae extending from the head, across the pronotum, and along the elytra; the elytra have small dusky spots in the apex of the cells, and the membrane is darker. Abdomen cream with pairs of suffuse dark bars dorsally on each segment. Male genitalia as in figure 3. Pygofer hook evenly curved. Style with foot nearly at right angles to shaft, with a short anterior point and a long posterior point which is longer than the foot and projects nearly straight posteriad from it. Aedeagus with small socket and a large, deep, and fairly thin phalicata which arises from near the middle of the socket and bears no processes except at extreme tip. The tip forms three projections, a short, pointed mesal one flanked on each side by a longer, stout process curving laterad at tip.

Holotype, male, Dixon Springs, Ill., July 15, 1948, Mills & Ross, on *Alnus rugosa*. Paratypes, all from Illinois and on *Alnus rugosa*, same data as holotype, 4♂; Eichorn, Aug. 17, 1951, Ross & Stannard, 2♂, 6♀; Dixon Springs, Aug. 30, 1951, Richards & Ross, 15♂.

This appears to be the only species of *Erythroneura* having *Alnus* as its host in southern Illinois. It has not been taken either in northern Illinois or Michigan.

Erythroneura frisoni n. sp.

Also allied to *spatulata*, this species is differentiated on the outcurved processes of the phalicata and the slightly transverse oval of its cross-section. From *jocosa* it differs in the long posterior point.

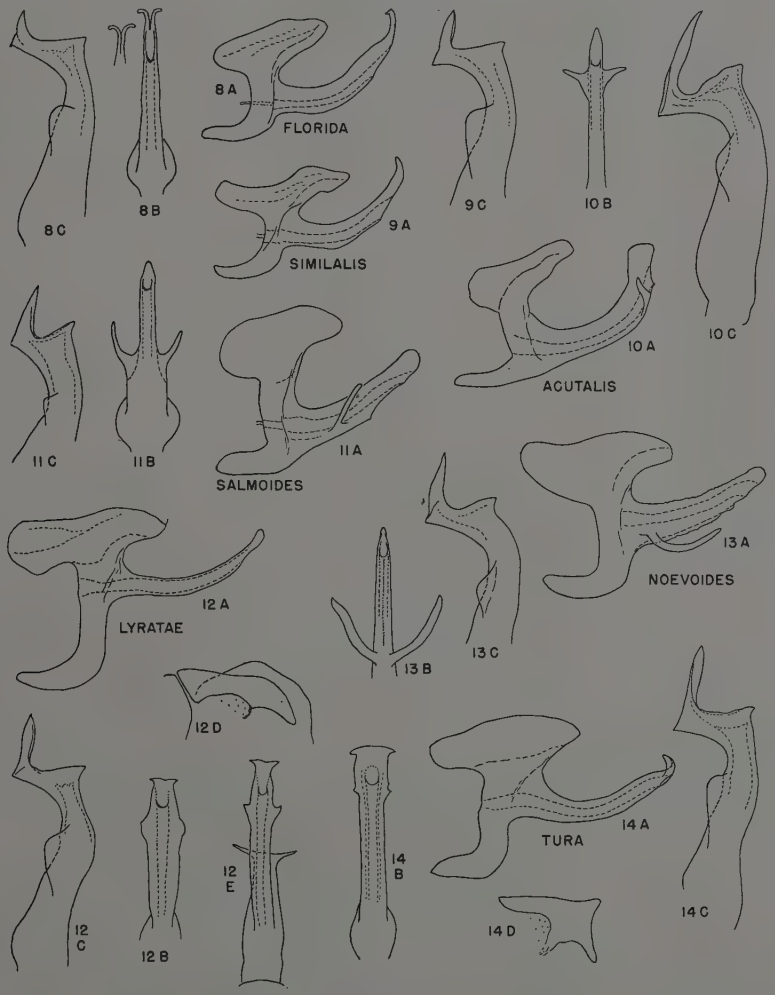
Length 2.8 mm. Color cream with a pair of pale red vittae extending over the head and pronotum, and two red vittae extending almost the full length of each elytron. Male genitalia as in figure 5. Pygofer hook evenly curved. Style with foot slightly angled back on shaft, with a sharp but short anterior point and a very long, sharp posterior which is nearly as long as foot and projects directly posteriad from it. Aedeagus with phalicata arising from near middle of socket, wider laterally than dorso-ventrad, slightly curved upwards, and with processes only at extreme tip. Tip divided into a truncate and somewhat crestlike mesal portion and a pair of lateral processes which are short, stout, and angled abruptly laterad.

Holotype, male, Gibsonia, Ill., Oct. 2, 1934, Frison & Ross.

Erythroneura verdana n. sp.

This species is a very close relative of *victorialis* Knull, differing from it in lacking the V-shaped red markings so characteristic of *victorialis*, and in having the mesal process of the phalicata as long as the lateral ones.

Length 2.8 mm. Color pale greenish yellow except for a red triangle in the apex of the clavus, occupying about half of it. When the wings are folded this makes a conspicuous red triangle in sharp relief against the greenish background. Male genitalia as in figure 7. Pygofer hook evenly rounded. Style with foot nearly at a right angle to shaft, with a moderately long



FIGURES 8–14. Male genitalia of *Erythroneura*. *A*, lateral aspect of aedeagus; *B*, ventral aspect of phalicata of paratype; *C*, style; *D*, lateral aspect of pygofer hook; *E*, ventral aspect of aedeagus of holotype. Except for figures 8*A* and 9*A*, all *A*, *B*, and *E* drawings are 1.5 times the magnification of the others.

anterior point directed mostly laterad, and a slightly longer posterior point projecting at right angles to the foot. Phalicata arising out of middle of socket, bent sharply ventrad at base, then angling dorsad, deep but fairly narrow, the apex divided into three parts, a finger-like mesal projection, and a pair of lateral projections curving slightly laterad and ending in a round, lateral angulation.

Holotype, male, Alum Cave area, Great Smoky Mountains National Park, Tenn., Sept. 1, 1948, Ross & Stannard.

Erythroneura aesculella n. sp.

A close ally of *rubroscuta* (Gillette), this species differs so far as known only in the ventral position of the ventral processes of the aedeagus.

Length 3.2 mm. Color creamy yellow with two transverse red bands across the body, one occupying the entire exposed area of the thoracic nota, the other crossing the middle of the elytra, as in *rubroscuta*. Genitalia as in figure 6. Pygofer hook evenly curved. Style slightly angled back on the shaft, with a short, sharp anterior point projecting mostly laterad, and a slightly longer posterior point extending directly posteriad from the foot. Aedeagus with phalicata arising a little dorsad of the middle, and with a pair of stout, long ventral processes arising some distance below the base of the phalicata. Phalicata nearly straight, upturned only toward apex, with lower margin serrate, and apex produced dorsad into a mesal crest appearing pointed from ventral view.

Holotype, male, Brownfield Woods, Urbana, Ill., Aug. 9, 1948, Becker & Ross, on *Aesculus glabra*. Paratypes, same data, 21♂; same data but July 28, Sanderson et al., 9♂; April 29, 1920, 1♂; Cottonwoods, Urbana, Ill., July 20, 1920, 2♂; Alum Cave area, Great Smoky Mountains National Park, Sept. 1, 1948, Ross & Stannard, on *Aesculus* sp., 2♂.

This species and *rubroscuta* occur together abundantly at Urbana, but no intergrades between the two have been found to date. Both are confined to *Aesculus*, except for occasional strays on surrounding trees.

Erythroneura florida n. sp.

This and the following species appear to be somewhat ancestral to the species related to *victorialis*, in that the aedeagus is divided into a pair of long processes at the apex. They differ, however, in having no mesal projection between the lateral ones.

Length 2.9 mm. Color cream with typical red vittae, a pair extending across the head and over the pronotum, and another pair on each elytron. Male genitalia as in figure 8. Pygofer hook evenly curved. Style with foot at almost a right angle to shaft, with a sharp angulation for the anterior point, and with the posterior point less than half length of foot, sharp, and curved very slightly mesad at tip. Phalicata arising below middle of socket, curved upward, deeper than wide, and with the apex divided into a pair of long, slender processes which curve laterad and dorsad. Other than these there are no lateral or ventral processes present.

Holotype, male, allotype, female, and 11♂, 20♀ paratypes, Perry, Fla., Dec. 17, 1949, Stannard et al., on *Myrica cerifera*.

There is some doubt as to whether or not these individuals were taken on their normal host plant, or whether they were simply feeding on the *Myrica* during the period when their regular host was defoliated. Other species of the group are known to have *Quercus* as their host, which would seem to favor the second alternative.

Erythroneura similalis n. sp.

The dorsal red stripe of this species resembles that of *lawsoniana* to a startling degree, but the two species are not at all closely related. From the preceding species, *florida*, the present one differs in the slightly shallower phalicata and the much longer posterior point, in addition to the distinctive dorsal red stripe.

Length 3 mm. Color cream with a dorsal red stripe extending from the head to the membrane of the elytra. This stripe occupies about half the head width, half the pronotum, and merges with the claval stripe of the elytra and then with the apex of the medial stripe. Male genitalia as in figure 9. Pygofer hook evenly curved. Style with foot at nearly a right angle to shaft,

with a short anterior point and a much longer posterior point which is nearly as long as foot and forms a slightly acute angle with it. Aedeagus with phalicata arising near middle; the phalicata is deeper than wide and is divided at apex into a pair of lateral processes almost exactly like those of *florida* (fig. 8B).

Holotype, male, and 2♂ paratypes (one without abdomen), Chiefland, Fla., Dec. 17, 1949, Stannard et al.; on *Quercus myrtifolia*.

Erythroneura acutalis n. sp.

In color and structure of aedeagus, this species is similar to *tenuispica* Beamer, but differs in having the elongate posterior point of the style at an acute angle with the foot.

Length 2.8 mm. Color cream with the usual red vittae down head and pronotum and along elytra. Male genitalia as in figure 10. Pygofer hook evenly rounded. Style with foot curved slightly back on shaft, anterior point represented only by an angular corner, posterior point elongate, longer than foot, and forming an acute angle with it. Aedeagus with phalicata occurring near ventral margin, the phalicata curved gently upward, slightly deeper than wide, with a pair of lateral projections near apex, and the apex itself produced dorsad into a small crest which is pointed as seen from ventral view.

Holotype, male, and 3♂ paratypes, White Spring, Fla., Dec. 11, 1949, Stannard et al. These specimens were taken sweeping a mixture of *Salix*, *Myrica*, and two species of *Quercus*, occurring in a small humid pocket of an otherwise dry pine woods.

Erythroneura salmoides n. sp.

The general pattern of genitalia indicates a kinship of this species with *tenuispica* Beamer, from which it differs markedly in the basal position of the ventral processes of the phalicata and the broad, sharp posterior point of the style.

Length 2.8 mm. Color pale cream with the usual vittae over the head and pronotum and along the elytra, the vittae moderately narrow and a delicate salmon pink; the apices of the discal cells each have a dusky spot. Male genitalia as in figure 11. Pygofer hook evenly rounded. Style with foot angled slightly back on shaft, with anterior point represented only by an angulation, and with posterior point as long as foot and broad at base, tapering to a sharp point, and making an acute angle with the instep. Aedeagus with phalicata arising close to ventral margin, the phalicata nearly straight with a slight dorsal crest at apex, and with a pair of latero-ventral processes arising just below middle; below this point the phalicata is fairly robust, but beyond it narrows markedly.

Holotype, male, Rocky Branch Cr., Oliver, Ill., Apr. 22, 1949, Ross & Stannard.

Erythroneura noevoides n. sp.

This species is a member of the *noeva* complex, differing from *noeva* Gillette in the widely divergent ventral processes of the phalicata, and from *hamata* Beamer in the posteriorly directed posterior point of the foot.

Length 3 mm. Color cream with typical vittae on head, pronotum and elytra, the vittae pale red and not very conspicuous. Male genitalia as in figure 13. Pygofer hook evenly curved. Style with foot slightly angled back on shaft, the anterior point represented by an angulation, the posterior point as long as the foot, and held at nearly a right angle with it. Aedeagus with phalicata arising near middle of socket, the phalicata deeper than wide, curving slightly dorsad, with both upper and lower margins slightly serrate, the apex with a small dorsal crest, and with a pair of long, divergent ventral processes arising from near the base and curving latero-posteriad.

Holotype, male, Marshall, Ill., Apr. 22, 1949, Ross & Stannard. Paratypes, Rocky Branch Cr., Oliver, Ill., Apr. 22, 1949, Ross & Stannard, 2♂ (abdomens only).

Erythroneura lyratae n. sp.

This species is a close relative of *volucris* Beamer, from which it differs in the evenly rounded pygofer hook and the lack of ventral flanges on the aedeagus.

Length 3 mm. Color a pale cream, with the usual vittae across head and pronotum, these vittae yellowish or partially red, but always with a greenish caste which is quite pronounced;

apex of elytral cells with a faint dusky spot at cross-veins. Male genitalia as in figure 12. Pygofer hook evenly rounded. Style with foot about at right angles to shaft, the anterior point represented by an angulation, the posterior point as long as the foot and held at right angles to it. Aedeagus with phalicata arising from near middle, the phalicata curving gently dorsad, slightly wider than deep, narrowed near tip into a slightly incised apex with a pair of small, lateral sharp points; basad of this the phalicata bears a pair of small lateral flanges which may end in sharp points.

Holotype, male, allotype, female, and numerous ♂ and ♀ paratypes, Grantsburg, Ill., Aug. 17, 1951, Ross & Stannard, on *Quercus lyrata*. Additional paratypes are from Dale, Ill., July 15, 1947, L. J. Stannard, on *Quercus lyrata*.

Whereas this species seems to be fairly common on *Quercus lyrata* in southern Illinois, we have taken only a single stray of *volucris* on this host. The host of *volucris* is not yet known for certain, but it may be *Crataegus*.

Erythroneura tura n. sp.

Another close relative of *volucris*, this species differs in having a sharper dorsal point on the pygofer hook, and no longutidinal ventral flanges on the phalicata.

Size and color as in *lyratae* (see above). Male genitalia as in figure 14. Pygofer hook with a sharp dorsal projection, giving it a crested appearance. Style as in *lyratae*. Phalicata also similar in most points, but having only minute lateral projections just below the opening of the gonopore, and having the apex with ventral aspect arcuate.

Holotype, male, Mermet, Ill., Sept. 20, 1950, Ross & Evers, on *Quercus phellos*. Paratype, Karbers Ridge, Ill., Apr. 22, 1935, T. H. Frison, ♂.

Erythroneura zephyr n. sp.

The aedeagus places this species as a close relative of *cornipes* Beamer, but it differs in the different type of style and the shape of the apex of the phalicata.

Length 3 mm. Color cream with the usual vittae on head, pronotum, and elytra a reddish pink and only moderately bright. Male genitalia as in figure 15. Pygofer hook evenly rounded. Style with apex curving into foot; anterior point produced as a short, sharp projection; posterior point over half length of foot and projecting almost directly posteriad from it. Aedeagus with phalicata arising from near middle of socket; phalicata curved dorsad, its apex widened into a pair of large, angular lateral projections, with a small, pointed mesal projection arising between them.

Holotype, male, North of Marion, Ill., Sept. 21, 1950, on *Quercus imbricaria*, Ross & Evers. Paratype, Alma, Ill., Sept. 21, 1950, on *Quercus imbricaria*, Ross & Evers, ♂.

Although both specimens of this species were taken on *Quercus imbricaria*, it is possible that both were drifts, and this oak should not yet be regarded as the host of this leafhopper.

Erythroneura wysongi n. sp.

This species is most curious in that the ventral aspect of the aedeagus looks like an arrow-head exactly like that of *sagittata*, but the projecting parts are reversed. In *sagittata* it is the phalicata which bears the lateral triangular parts, whereas in *wysongi* it is the ventral processes.

Length 2.8 mm. Color: venter blackish, face reddish brown; dorsum cream color along the sides, the red vittae having widened and met along the meson to form a continuous central brick red band from the tip of the head to the end of the corium. Male genitalia as in figure 16. Pygofer hook evenly rounded. Style not greatly narrowed below the foot, anterior point short and projecting laterad, posterior point broad at base, tapering evenly to a sharp point, and about half length of foot. Phalicata arising from near middle of socket, fairly straight and nearly tubular; ventral processes arising from base of phalicata, extending almost to its tip, and each with a wide lateral expansion, the two together with the phalicata giving an arrow-head appearance to the ventral aspect.

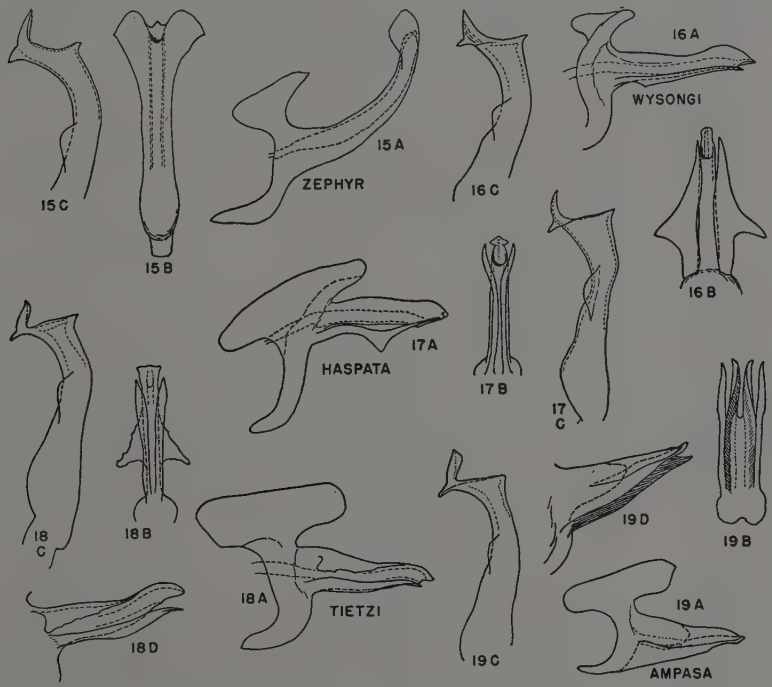
Holotype, male, Bemis Woods, Cook Co., Ill., July 2, 1949, Ross & Stannard, on *Crataegus mollis*. It is highly likely that this specimen was collected on its true host, since many other related species feed on *Crataegus*.

This species is named in gratitude to Noel B. Wysong, Forestor of the Cook County Forest Preserve District, who has been of inestimable help in assisting with our collecting program in Cook County.

Erythroneura haspata n. sp.

This species is closest to *plena* Beamer and *wysongi* n. sp., differing most conspicuously from the former in the ventral process on the ventral process of the aedeagus, and from the latter in the ventral direction of these processes.

Length 2.9 mm. Color cream with the face and the usual vittae on head, pronotum, and elytra lemon yellow to moderately bright red. Male genitalia as in figure 17. Pygofer hook



FIGURES 15–19. Male genitalia of *Erythroneura*. *A*, lateral aspect of aedeagus; *B*, ventral aspect of phalicata; *C*, style; *D*, quartering view of phalicata. *A*, *B*, and *D* drawings are 1.5 times the magnification of *C* drawings.

evenly curved. Style with apex broadening rather imperceptibly into foot, anterior point short, posterior point about twice as long and curving slightly mesad, otherwise nearly at right angles to instep. Aedeagus with phalicata arising fairly close to dorsal margin of socket; phalicata slightly deeper than wide, nearly straight and produced at apex into a pair of small projections directed laterad; ventral processes arising just below base of phalicata, sinuate, as long as phalicata, and each bearing a triangular ventral projection just beyond middle.

Holotype, male, Thornton, Ill., Sept. 7, 1949, Ross & Stannard, on *Corylus americana*. Paratype, Eichorn, Ill., Mar. 27, 1935, Ross & Mohr, ♂.

Erythroneura tietzi n. sp.

A close relative of *sagittata* Beamer, this species differs primarily in the characters of the foot. In *sagittata* the posterior point is oblique with the foot and tapers gradually to a curved apex,

as in *funesta* Beamer and several other species; in *tietzi*, on the other hand, the posterior point is acute with the foot and of equal thickness almost to the tip, resembling the condition found in *electa* McAtee.

Length 2.8 mm. Color: venter, including face, dark brown, almost black; dorsum with head and pronotum cream with wide dark brownish-red vittae, and with elytra brownish olive with two creamy marks formed when the wings are folded, an anterior triangular one and heart shaped one which ends at the edge of the corium; the reddish vittae are present on the elytra but obscured and modified by the above pattern. Male genitalia as in figure 18. Pygofer hook evenly curved. Style curving only slightly into foot, anterior point short, blunt, and projecting chiefly laterad, posterior point longer and acute with instep. Aedeagus with phalicata arising near middle of socket; phalicata nearly straight, the tip with the dorsal margin sloping ventrad, the sides with wide, triangular expansions, the two together forming an arrow-head shaped structure; ventral processes arising from base of phalicata and appressed to it for their entire length.

Holotype, male, and allotype, female, Bemis Camp, Cook Co., Ill., Jn. 21, 1949, Ross & Tietz, on *Crataegus mollis*. Paratypes, same locality and host, Jn. 21, Jly. 2, and Sept. 9, 1949, 16♂, 22♀.

It is perhaps significant that we have taken this species only in extreme northern Illinois, whereas its relative *sagittata* has been collected only in southern Illinois.

Erythroneura ampasa n. sp.

This species is similar to *tietzi* in color and in shape of style, but exceedingly different in the foliaceous divisions of the aedeagus.

Length 2.8 mm. Color as for *tietzi*, described above. Male genitalia as in figure 19. Pygofer hook evenly curved. Style with foot nearly at right angles to shaft, the anterior point short and slender, the posterior point longer and robust for nearly its entire length, and acute with the instep. Aedeagus with phalicata arising from near base of socket, the phalicata broad at base, tapering gradually to a sharp apex, and cleft down meson to near midpoint; each half is again divided into two flat processes which overlap slightly and are difficult to distinguish. The ventral pair of flat processes may represent the ventral processes which in other species are more nearly finger-like.

Holotype, male, Kappa, Ill., Sept. 29, 1950, Ross & Stannard, on *Crataegus mollis*.

MACULATA GROUP

Erythroneura imbricariae n. sp.

This species is apparently most closely related to *gillettei* Beamer, differing in the entirely different shape of the processes of the aedeagus and the short posterior point.

Length 2.8 mm. Color creamy with faint reddish dots and bars of the usual type for the group. Male genitalia as in figure 20. Pygofer hook short, broad at base, curved ventrad at apex. Style with foot slightly obtuse with shaft, with sharp heel but with both anterior and posterior points represented only by an angulation. Phalicata arising from about middle of socket, angled sharply dorsad, and bearing a pair of recurved thornlike processes at apex, and having a pair of elongate and slender ventral processes arising from its base and directed latero-dorsad. From posterior view these processes coincide to a remarkable degree with the slender lateral extensions of the socket.

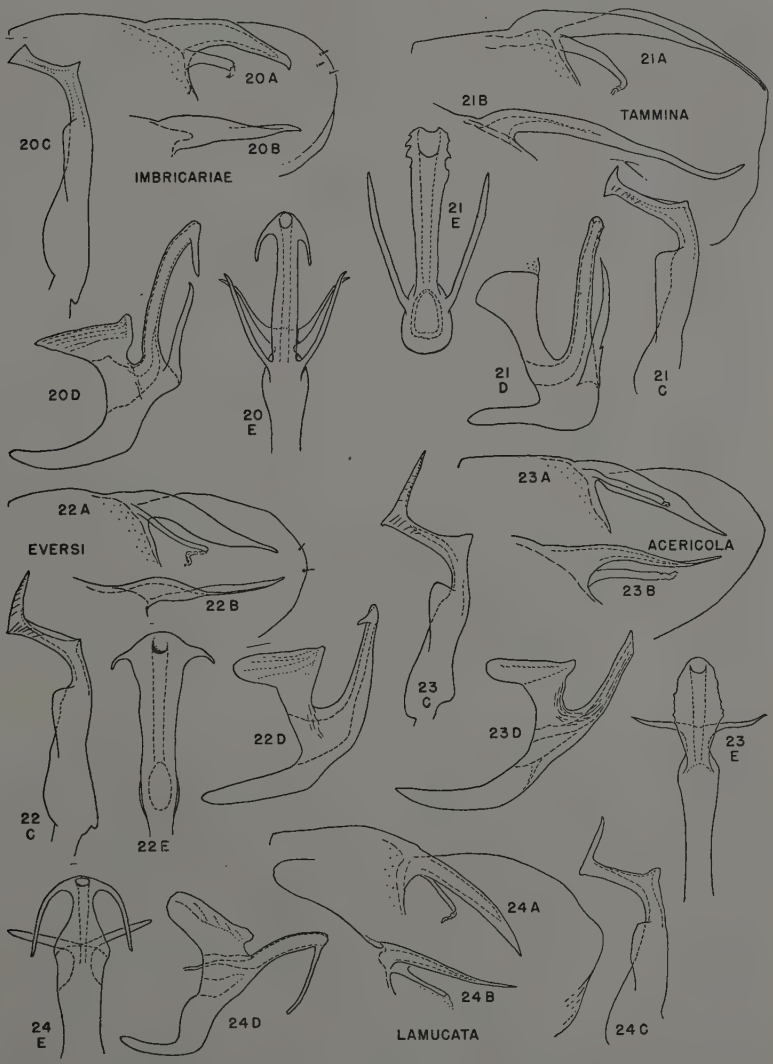
Holotype, male, Fairfield, Ill., July 14, 1948, Mills & Ross, on *Quercus imbricaria*. Paratypes, 10♂, all from *Quercus imbricaria* except two from a hybrid *Q. imbricaria* x *falcata*, from Danville, north of Marion, Monticello, Kickapoo State Park, and Shawneetown, Ill.

Shingle oak, *Q. imbricaria*, is undoubtedly the true host for this species. It is a fairly constant component of the shingle oak fauna, although never as abundant as some of the other members of the genus such as *confirmata* McAtee.

Erythroneura tammina n. sp.

This species is probably most closely related to the preceding, differing in lacking the apical processes of the phalicata, and in details of all other parts of the male genitalia.

Length 2.9 mm. Color as for *imbricariae*. Male genitalia as in figure 21. Pygofer hook elongate, wide at base and gradually tapering to a slender, whiplike apex. Style with foot oblique to shaft, with a small, angular anterior point, and a slightly longer, sharp posterior point. Aedeagus with phalicata arising near ventral margin of socket; phalicata angled sharply dorsad, wider than deep, expanding to apex which is bordered with a few serrations, and with a pair of



FIGURES 20–24. Male genitalia of *Erythroneura*. *A*, *B*, lateral and dorsal aspects, respectively, of pygofer hook; *C*, style; *D*, *E*, lateral and ventral aspects, respectively, of aedeagus. *D* and *E* drawings are 1.5 times the magnification of the others.

long slender processes arising from its base. The left process has a slight notch near base, the right process is smooth throughout.

Holotype, male, Northwest of Tamms, Ill., Sept. 20, 1950, Ross & Evers.

Erythroneura eversi n. sp.

A close relative of *lata* Beamer, this species differs in the longer posterior point and the sharp lateral processes at the apex of the phalicata.

Length 2.8 mm. Color cream with very pale yellow or slightly reddish markings of the type usual for the genus. Male genitalia as in figure 22. Pygofer hook short, sinuate, broad at base and narrowed to a slender, finger-like tip. Style with foot oblique to shaft, the anterior point represented only by an angulation, the posterior point nearly as long as foot and just a trifle oblique to the instep. Phalicata arising near ventral margin of socket, bent dorsad at a distinct angle, lateral aspect wide at base, tapering to apex, posterior aspect just the reverse, widening toward apex which is produced laterally into a pair of fairly long, sharp processes curving slightly backwards on the phalicata.

Holotype, male, Northwest of Tamms, Ill., Sept. 20, 1950, Ross & Evers, on *Corylus americana*. Paratypes, same data, 10♂; Olmsted, Ill., Jly. 15, 1948, Sanderson & Stannard, 2♂; Rocky Branch, Clark Co., Ill., Sept. 14, 1949, Stannard & Ross, on *Corylus americana*, 1♂.

This delicate hazel species is named for Robert A. Evers, Assistant Botanist, Illinois Natural History Survey, who has been of tremendous aid to this project in identifying plant species and in taking us to unusual and productive collecting areas.

Erythroneura acericola n. sp.

This species also resembles *lata* Beamer superficially, but differs in that the phalicata narrows rather than widens at the apex.

Length 2.9 mm. Color cream with light red markings of the type usual for the group. Male genitalia as in figure 23. Pygofer hook fairly short, basal part broad, tapering to a sharp point. Style with foot nearly at right angles to shaft, the anterior point minute, the posterior point slightly longer than foot and extending directly posteriad from it. Aedeagus with very long ventral extension on socket, phalicata arising from near middle of socket; phalicata curving sharply dorsad, lateral aspect slender and regular, posterior aspect wider, narrowed at base and widest near middle, tapering again to apex, this latter portion finely serrate.

Holotype, male, Brownfield Woods, Urbana Ill., Aug. 9, 1948, Becker & Ross, on *Acer saccharum*. Paratypes, same data, 5♂; Marshall, Ill., Apr. 22, 1949, Ross & Stannard, 1♂; Funks Grove, McLean, Ill., Aug. 3, 1949, on *Acer saccharum*, Mills & Ross, 1♂; Foley's Woods, southwest of Paris, Ill., Apr. 22, 1949, Ross & Stannard, 1♂.

Erythroneura lamucata n. sp.

This species differs from *maculata* (Gillette), its closest relative, in the longer posterior point and the longer and down-curved apical processes of the phalicata.

Length 2.8 mm. Color cream with pale red markings typical of the group. Male genitalia as in figure 24. Pygofer hooks of only moderate length, bladelike and curved slightly ventrad. Style with foot slightly oblique to shaft, the anterior point merely an angulation, the posterior point nearly as long as foot and at about a right angle with instep. Aedeagus with phalicata arising near dorsal margin, the phalicata widest near base, tapering to apex, the ventral aspect vasiform; the apex of the phalicata gives rise to a pair of long, down-curved lateral processes which are as long as the phalicata.

Holotype, male, Lake Bloomington, Ill., Sept. 29, 1950, Ross & Stannard, on *Rhus toxicodendron*. Paratypes, same data, 1♂; Valmeyer, Ill., Jn. 18, 1948, Smith & Stannard, 1♂.

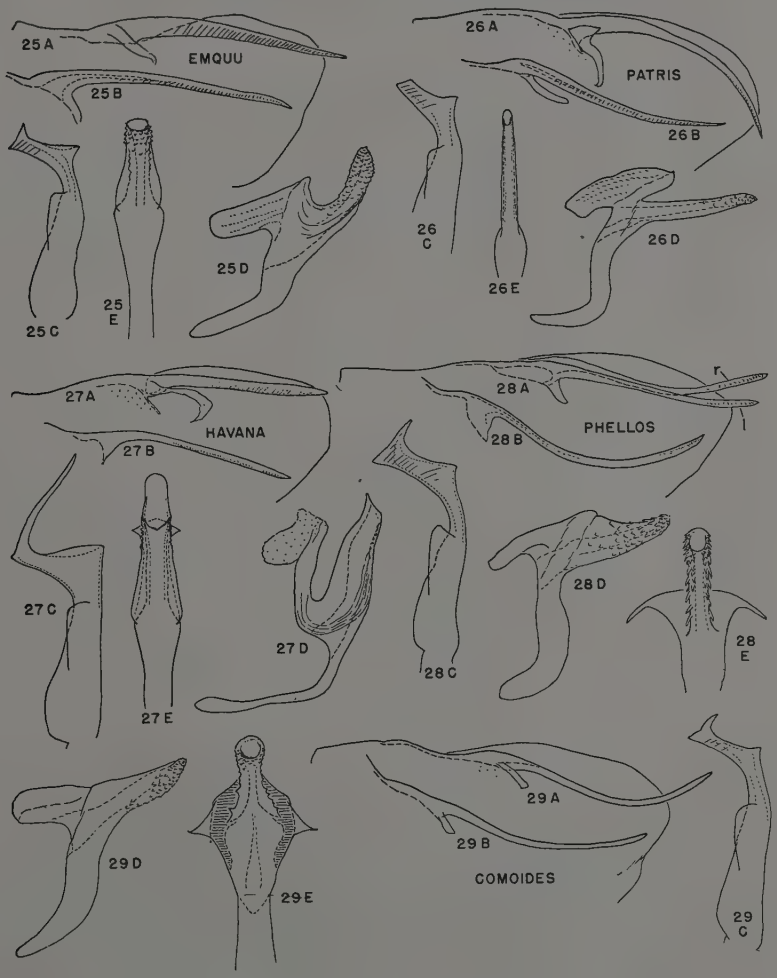
Erythroneura emquu n. sp.

This species most closely resembles *campora* Robinson, but differs markedly in the phalicata.

Length 3 mm. Color cream with fairly bright red spots of the usual pattern for the group. Male genitalia as in figure 25. Pygofer hook elongate, nearly straight and bladelike, tapering evenly from base to apex. Style with foot slightly oblique with shaft, the anterior point a sharp

angle, the posterior point a little longer and also forming a sharp angle. Phalicata arising from about middle of socket, curved sharply dorsad, its apical portion covered with minute teeth, and with a ventral flange along each side extending from base to near apex.

Holotype, male, Perry, Fla., Dec. 17, 1949, Stannard et al., on *Myrica cerifera*. Paratypes, same data, 1♂; Chiefland, Fla., Dec. 17, 1949, Stannard et al., on *Quercus myrtifolia*, 3♂.



FIGURES 25–29. Male genitalia of *Erythroneura*. *A*, *B*, lateral and dorsal aspects, respectively, of pygofer hook; *C*, style; *D*, *E*, lateral and ventral aspects, respectively, of aedeagus. *D* and *E* drawings are 1.5 times the magnification of the others.

Erythroneura patris n. sp.

Most closely related to *interna* Beamer, this species is distinguished by the less curved pygofer hook and the more slender phalicata.

Length 2.8 mm. Color cream with the usual pattern of light red markings typical for the group. Male genitalia as in figure 26. Pygofer hook elongate and curved into a near quadrant, tapering from base to middle and from there nearly uniform to apex. Style with foot oblique to shaft, with a sharp heel but with the anterior and posterior points represented by only slight angulations. Phalicata arising near dorsal margin of socket, straight and slender, extending almost posteriad, the tip with a few small points.

Holotype, male, and 6♂ paratypes, Grand Tower, Ill., Oct. 7, 1947, on *Quercus stellata* (one on *Q. bicolor*).

Erythroneura havana n. sp.

This species resembles *gemina* Beamer most closely, differing in the thick lateral aspect of the phalicata.

Length 2.8 mm. Color cream with light red spots usual for the group. Male genitalia as in figure 27. Pygofer hook straight and moderately long, bladelike. Foot at nearly a right angle with shaft of style, the anterior point minute, the posterior point much longer than foot and held at an acute angle with it. Aedeagus with long ventral strap on socket; phalicata arising near base of socket, lateral aspect deep, with the apex narrowed, the whole held nearly upright; on each side the phalicata bears a flange which runs from the base to near the lower lip of the gonopore.

Holotype, male, Havana, Ill., July 2, 1934, DeLong & Ross.

Erythroneura phellos n. sp.

This species appears to be most closely related to *spinifera* Beamer, but differs markedly in the narrow ventral aspect of the phalicata.

Length 2.8 mm. Color cream with light red markings typical for group but each one slightly more elongate than usual. Male genitalia as in figure 28. Pygofer hook elongate and curved mesad and slightly dorsad (note that in figure 28A both the right (*r*) and left (*l*) pygofer hooks are drawn superimposed, and that each is single). Style with foot oblique to shaft, the anterior point simply an angle, and the posterior point longer, slender and sharp, slightly acute with instep and nearly half as long as foot. Aedeagus with phalicata arising from dorsal margin, short and trianguloid from lateral view, narrow and straight sided from ventral view, armed with numerous teeth; the dorsal portion of the socket is unusual in that, instead of narrowing above the phalicata, it widens and forms a large sclerotized plate out of which the phalicata arises.

Holotype, male, and 5♂ paratypes, Mermet, Ill., Sept. 20, 1950, Ross & Evers, on *Quercus phellos*.

Erythroneura comoides n. sp.

This is a sister species with the preceding, differing from it in the shorter, posterior point and the shape of the aedeagus.

Length 2.9 mm. Color cream with a fairly bright red lattice formed by the linking up of the ends of the usual marks of the group, giving the species the appearance of certain members of the Comes Group. Male genitalia as in figure 29. Pygofer hook elongate, slender, and curved gracefully both mesad and dorsad. Style with foot oblique to shaft, the anterior point short and sharp, the posterior point a little longer and also sharp, curved slightly over instep. Aedeagus with upper portion of socket expanded into a large, shield-shaped, sclerotized plate from which the phalicata arises: phalicata fairly short, lateral aspect narrowing toward tip, ventral aspect slightly vasiform due to a central constriction, and with serrate lateral margins.

Holotype, male, Chiefland, Fla., Dec. 17, 1949, Stannard et al., on *Quercus myrtifolia*. Allotype, female, Perry, Fla., Dec. 17, 1949, Stannard et al., on *Myrica cerifera*. Paratypes, same data as holotype, 1♂; same data as allotype, 1♂.

SEASONAL VARIATIONS IN RELATIVE ABUNDANCE OF *CYCLOPS VERNALIS* FISCHER, *CYCLOPS BICUSPIDATUS* CLAUS, AND *MESOCYCLOPS LEUCKARTI* (CLAUS) IN WESTERN LAKE ERIE, FROM JULY, 1946, TO MAY, 1948

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Examination of the limnological literature shows that very few year-round quantitative studies have been made on zooplankton. Most of the literature contains reports of data that have been gathered during the summer months. Extensive year-round research results on zooplankton and related limnological factors have been published by Kofoid (1908), Allen (1920), Birge and Juday (1922), Riley, (1940), and Pennak (1949). Several year-round limnological studies of western Lake Erie have been made (Chandler. 1940, 1942, 1944; Chandler and Weeks, 1945).

The purpose of this study was to make quantitative determinations of seasonal variations in temperature, in abundance of seston, and in abundance of two species of *Cyclops* and one species of *Mesocyclops* by making at least monthly collections at one meter intervals from surface to bottom for 21 months.

FIGURE 1. Outline map of western Lake Erie. The two crosses between South Bass and Rattlesnake Islands indicate where collections were made.

Appreciation is expressed to Dr. David C. Chandler and to Dr. W. J. Jahoda for their assistance both in the field and laboratory; to Miss Lois Redmond for preparation of graphs; to my associates at Kansas State Teachers College, who have helped on many occasions; and to The Franz Theodore Stone Institute of Hydrobiology for furnishing all of the field and laboratory equipment, which was used to gather data for this study.

DESCRIPTION OF AREA

Figure 1 shows the locations of the two stations where all collections were made. Station I was located about half-way between South Bass Island and Rattlesnake Island where the water was 10 meters deep. All collections were made at this location when an ice cover existed. Station II was located about 2 miles northwest of Station 1 where the water was also about 10 meters deep.

Collections were made at station II whenever an ice cover did not exist. Since there was considerable evidence that the limnological characteristics of the water in the area of these two stations is about the same (Chandler, 1940; Andrews, 1948), the data are treated as though they were collected at one station representative of this area of western Lake Erie.

MATERIALS AND METHODS

Quantitative zooplankton samples were taken at each meter from surface to bottom with a 10 liter plankton trap (Juday, 1916). All adult male and female *Cyclops* and *Mesocyclops* in each 10-liter sample were identified to species, counted, and recorded. Immature and naupliar stages were also recorded.

Water samples for purposes of making seston determinations were collected with a two-liter capacity modified Kemmerer water bottle. A two-liter sample was taken at the surface (zero meters), halfway (5 meters), and near the bottom (10 meters). These samples were thoroughly mixed and a one-liter sample centrifuged. Organic and inorganic determinations were made according to standard procedures discussed by Chandler (1942).

Temperatures were recorded at zero, 5, and 10 meters with a Negretti and Zambra reversing thermometer.

DISCUSSION OF RESULTS

Cyclops vernalis Fischer. *C. vernalis* (Coker, 1943, Marsh, 1918), which is probably the most widely distributed copepod in North America, was the copepod that occurred in greatest abundance in western Lake Erie during this study. The seasonal trends in abundance of males and females are given in figure 2. In order to have the numerical values in the curve as significant and representative as possible, all males and females in each 10-liter sample at the ten different depths were counted and recorded separately. Therefore each point on the male and female abundance curve represents the total number of males or females per 100 liters.

On July 29, 1946, when the first collections of this study were made, the water temperature was about 24° C and *C. vernalis* was abundant. There were 42 males and 361 females in the 100 liters sampled (fig. 2). The number collected decreased during July and August until on September 3 only 7 males and 61 females were collected. The population then increased until November 21 when 83 males and 442 females were collected. This was followed by a decline in population until on January 24, 1947, only 2 males and 6 females were collected. The water temperature on this date was 0.3° C. Although collections were made twice each month from January to May, only a few scattered specimens were collected. Figure 2 shows that an ice cover existed from December 6, 1946, to March 18, 1947. This species was not collected while an ice cover existed.

In the spring of 1947 (May 9), when the water temperature was 8.4° C., 12 females were collected. On May 19, none of this species was found in the collections, but on June 4, 141 males and 657 females were collected. These results would indicate that this species reproduces rapidly, building up a very high population within a week or two. Development from egg to adult requires only about eight days, according to Ewers (1930). One can readily see that collections made less often than once a month, every month of the year, would not obtain results that would indicate such tremendous fluctuations in population as shown by these data. As shown in figure 2 the peak population occurred on June 14 and July 5, 1947, when the water temperature was 17.6° and 21.7° C, respectively. During early August, the number collected decreased to a low of 6 males and 52 females. There was a slight fall peak in the population, as indicated by the September-October collections. Collections were not made in November, but this species was not in collections taken from December 2 to April 24, although collections

were made every month. The ice cover (fig. 2) in 1948 was of shorter duration than the ice cover of the previous year. It appeared on January 27 and disappeared on March 15. It is interesting to note that, again, *C. vernalis* was not collected under the ice cover. On April 24, 1948, when the temperature was 8.6° C, 4 males and 4 females were collected. This was apparently the beginning of the spring population.

This species occurred in greatest abundance when water temperatures were about 20° C. Decided decreases in abundance occurred when temperatures were as high as 24° C. This species began to appear in the spring when the water temperature increased to 8° or 10° C. The population began to drop off rapidly in the late fall when the water temperature decreased to about 10° C. When the water temperature was as low as 2° or 3° C, *C. vernalis* was not present in the collections. Chandler, 1940, found this species to occur from May to November,

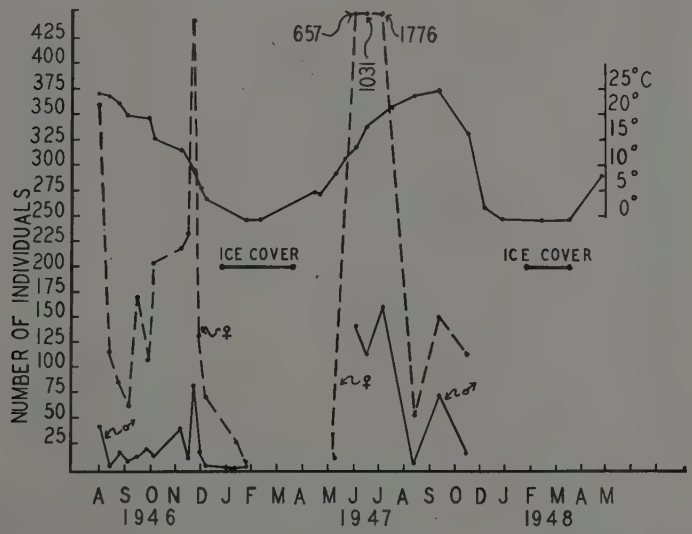

FIGURE 2. Seasonal variations in number of adult male and female *Cyclops vernalis*/100 liters. Each point on the curve represents the total number of individuals found in ten 10-liter samples taken at one meter intervals from surface to bottom. Duration of ice cover and variations in water temperature are also indicated.

but not to exceed 3 per liter. Optimum culturing temperature for this species is about 25° C according to Ewers (1936). The writer's experience in culturing this same species in Lake Erie water, with nutrients added, showed that the greatest rate of reproduction occurred when the culture was maintained at approximately 21° C. It appears that the optimum temperature for *C. vernalis* is about 20° C. in the natural environment in western Lake Erie as well as in the laboratory culture.

Cyclops bicuspidatus Claus. *C. bicuspidatus* was described by Marsh (1918) as a limnetic species, characteristic of the Great Lakes. Ewers (1930) stated that it was a deep water species of Lake Erie. Chandler (1940) found *C. bicuspidatus* throughout the year with the peak of abundance occurring in May or June. This species never was present in numbers exceeding 7 per liter. This study has shown *C. bicuspidatus* to be a cold water form which occurred as the most abundant

cyclops in western Lake Erie for only a brief period in the spring, when a maximum of 11 per liter was found. It never occurred in as great abundance as did *C. vernalis*, which reached a maximum of 19 per liter.

When this study was begun July 29, 1946, *C. bicuspidatus* was not present in the collections. Although collections were made at least once each month from July until January, only an occasional specimen of this species was collected (fig. 3). On January 11, 1947, thirteen females were collected. The water temperature at this time was about 2° C. Males did not appear in the collections until March 3, when 6 males and 20 females were collected in the 100 liter sample. At this time the water temperature was about 0.3° C. Males and females were found in all collections throughout the winter and spring. On June 4 and 14,

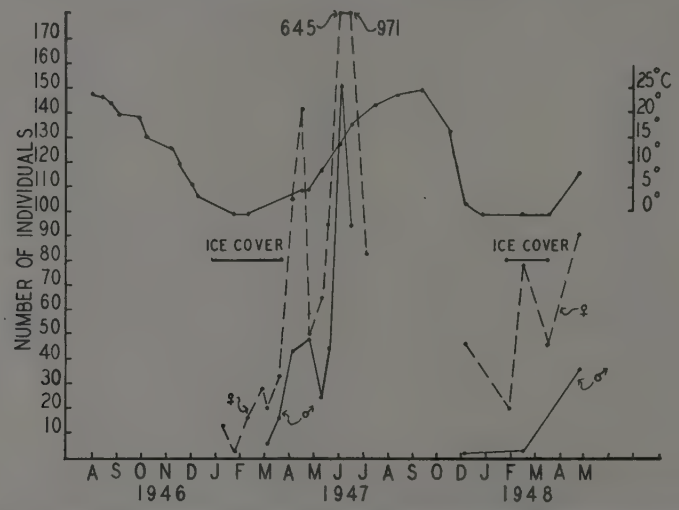

FIGURE 3. Seasonal variations in number of adult male and female *Cyclops bicuspidatus*/100 liters. Duration of ice cover and variations in temperature are also indicated. (For details, see legend of fig. 2.)

when the water temperature was about 15° C, the peak of the *C. bicuspidatus* population occurred. Examination of figure 3 shows that 94 males and 971 females comprised the June 14 collection. On July 5, when the water temperature was 21.7° C and the *C. vernalis* population was at one of its peaks, the *C. bicuspidatus* population consisted of only 83 females and no males.

Throughout the summer and fall of 1947, *C. bicuspidatus* was not found; although collections were made at least every month, excepting November. On December 2, 1947, when the water temperature was about 2° C, 2 male and 46 female *C. bicuspidatus* were collected. Both males and females were collected each month until April 24 when the last collection was made. It may be seen in figure 3 that the population was building up when this study was terminated. If collections had been continued throughout May and June, an annual population peak would probably have been detected as it was in 1947.

An ice cover existed from December 6, 1946, to March 18, 1947, and from January 27 to March 15, 1948. Examination of figure 3 shows that *C. bicuspidatus* was first collected each year either just before or right after the ice cover formed.

The temperature of the water was about 2° C in January, 1947, when they first appeared, and about 1.7° C in December, 1947, when they first appeared. The population apparently reached its peak in the first part of June, 1947, when the water was about 14° C. During both years, the *C. bicuspidatus* population decreased rapidly and disappeared as soon as the water temperature reached about 15° C.

Only scanty information concerning the annual variations in populations of this species can be found in the literature. Ewers (1930) stated that *C. bicuspidatus* may be found in shallow waters in spring and autumn and that it goes to deeper waters of western Lake Erie in June. The results of this study indicated that from July to December this species was not present at any depth in western Lake Erie. Moore (1939) collected *C. bicuspidatus* during the summer and fall at Douglas Lake in Michigan. Langford (1938) collected it, but the numbers of

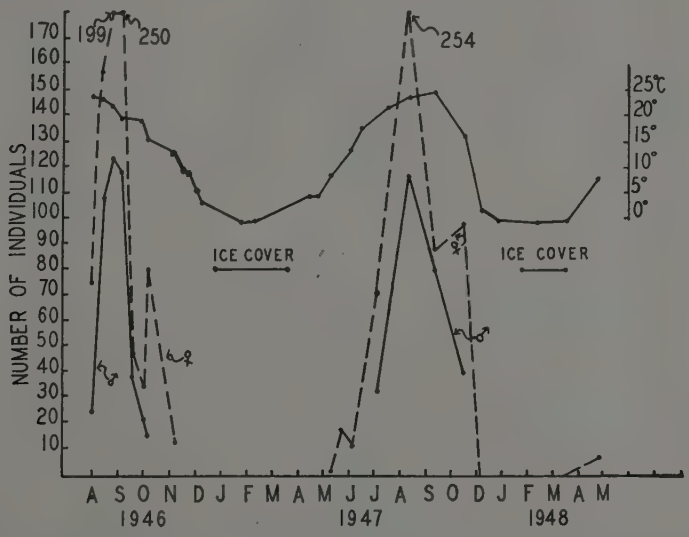

FIGURE 4. Seasonal variations in the number of adult male and female *Mesocyclops*/100 liters. Duration of ice cover and variations in temperature are also indicated. (For details, see legend, fig. 2.)

C. bicuspidatus he collected were lumped with other species; thus it was difficult to tell when the peak of the populations occurred. Chandler (1940) collected it the year-round with very few specimens being taken during the summer. Pennak (1949) collected *C. bicuspidatus* every month of the year in seven different mountain lakes in Colorado, but it was not a species that was characteristic of any particular time of the year. During this study in western Lake Erie, *C. bicuspidatus* was conspicuously monocyclic, appearing only throughout late winter and early spring.

Mesocyclops leuckarti (Claus). Marsh (1918), Ewers (1930), and Chandler (1940) list this species as *Cyclops leuckarti* Claus. Coker (1943) treats the synonyms that have been variously used for this species and gives supporting evidence for the correct name being *M. leuckarti* (Claus). Reports of population studies in North America on *M. leuckarti* are scarce. Cultured populations have been studied by Ewers (1936), but to the writer's knowledge, the only quan-

titative year-round information existing on this species is in Chandler's (1940) paper. He reports *C. leuckarti* as being present in most collections, being most numerous from June to September with a maximum of 6 per liter.

When this study was begun, July 29, 1946, 24 males and 75 females per 100 liters were collected (fig. 4). The population increased rapidly after that, reaching a peak of 118 males and 250 females in early September. It is worthy of note that the peak population of *C. bicuspidatus* and *C. vernalis* far exceeded the peak population of *M. leuckarti*, which reached a peak abundance of 4 per liter. Specimens of *M. leuckarti* were last found during 1946 on November 6, when 12 females were collected. It did not appear in any of the monthly collections during the fall and winter. On May 9, 1947, one female specimen was collected, but no males were found until July 5, when 32 males and 71 females were collected. This species was collected in greatest abundance in mid-August of the second year (1947). During September and early October, the population decreased until October 14, when 39 males and 98 females were collected. Since no collections were made in November, it is not known whether or not this species was still present. On December 2, *M. leuckarti* were not found in the collections, and no more specimens of *M. leuckarti* were collected until April 24, when 6 females comprised the catch.

The temperatures at which *M. leuckarti* began to occur in the collections and the temperatures when they began to disappear from the collections were quite similar both years. *M. leuckarti* began to appear in the collections when the water reached about 8° C. It reached a peak population at about 22° C, and it began to disappear from the collections when the water temperature decreased to about 13° C.

Sex ratios. There is a paucity of information concerning the sex ratios of copepods in natural populations. Since the sexes were treated separately in this study, it is possible to see (figs. 2, 3, 4) the trends in relative abundance of males and females for the three species. The curves in figure 5 give the sex ratios of all 3 species throughout the entire study.

The ratio of females to males is high in *C. vernalis;* however, inspection of figure 5 shows that the extent to which females outnumber males is highly variable. On July 29, 1946, female *C. vernalis* were 8.6 times more numerous than males, whereas on August 12, females outnumbered males 28.8 times. This was the highest ratio between males and females. The smallest amount that females outnumbered males was 2.1 times in September, 1947. When all male and female individuals that were collected during the entire study were compared, the females on the average outnumber the males 9.5 times. Apparently the high reproductive potential of the female makes it unnecessary to have many males produced. *C. vernalis* females produce 100 to 150 eggs per clutch, and as many as 8 clutches may be produced following a single copulation. A new clutch may be produced every third day and it takes only about ten days to develop from egg to maturity (Ewers, 1936). Knowing this, it is easily understood how populations of *C. vernalis* can build up so rapidly and maintain a high population.

Females of *C. bicuspidatus* usually begin to appear in the collections about a month before the males, and the males usually disappear from the collections about a month before the females (fig. 3). On January 11 and 24 and February 11 and 26, 1947, only, females outnumbered males 13, 2, 16, and 28 times, respectively. In December, January, and February of the following year, the females outnumbered males 23, 20, and 26 times, respectively. During March, April, May, and June, when the population was apparently as well stabilized as it ever got, the females on the average outnumbered the males 3.3 times. The reproductive capacity of *C. bicuspidatus* was found to be much less than that of *C. vernalis*. *C. bicuspidatus* only produces from 50 to 80 eggs per clutch, and it requires about a month to pass from egg to maturity. These factors probably accounted for the fact that *C. bicuspidatus* never occurred in as great abundance as did *C. vernalis*.

Females do not greatly outnumber the males of *Mesocyclops leuckarti* (figs. 4, 5). When this species began to show up in the collections in the spring, the females occurred first, and in the fall, when the species began to disappear from the collections, the males disappeared first. During these times, the females outnumbered the males from 6 to 17 times. However, after males began to appear, the ratio of females to males stayed quite uniform. In collections where both males and females were found, the females outnumbered the males from 1.1 to 5.3 times with the average being 2.2 females to one male. In *M. leuckarti* the reproductive capacity of the female is comparatively low. Only about 40 eggs are produced

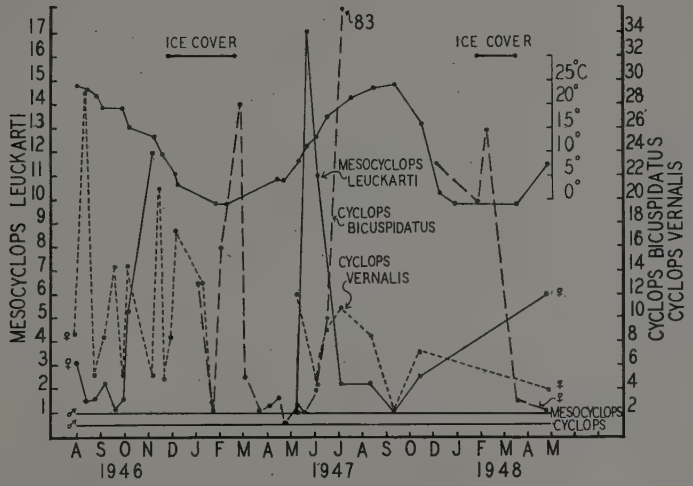

FIGURE 5. Seasonal variations in sex ratios of *Cyclops vernalis*, *Cyclops bicuspidatus* and *Mesocyclops leuckarti*. The male population was assigned a value of one and a straight line drawn to represent it. Each point on the curve indicates the number of times the females exceeded the males of the same species. Ice cover and temperature are also indicated.

TABLE 1

Monthly variations in number of copepodite and naupliar stages per 100 liters from April, 1947, to April, 1948.

Month-Year	No. of copepod. per 100 liters	No. of naup. per 100 liters	Month-Year	No. of copepod. per 100 liters	No. of naup. per 100 liters
April, 1947	19	1039	October	136	1257
May	221	4009	December	22	83
June	950	3114	January, 1948	none	2
July	1047	3237	February	none	7
August	680	4596	March	none	74
September	217	not counted	April	16	3728

in a clutch, and it takes about 20 to 30 days for an adult to develop from an egg (Ewers, 1936). From the results of this study, *M. leuckarti* apparently requires about one male for every two females. This is a much higher percentage of males than was found to be characteristic of *C. vernalis* and *C. bicuspidatus*.

Copepodite and Nauplii. During the last year of this study, all copepodite and naupliar stages of each sample were counted and recorded (table 1). When more than one collection was taken in a month, the results were averaged. It can be seen by examination of table 1, that the greatest number of copepodite stages

were collected in July, August, and September. In mid-June, *C. bicuspidatus* adults reached their peak population, and in July *C. vernalis* adults reached their peak population. Since *C. vernalis* passes from egg to adult in about a week, it was believed that most of the copepodite stages collected in July were *C. vernalis*. The greatest number of nauplii were collected in August. Since *C. bicuspidatus*, which reached its adult peak population in mid-June, requires a month or more to pass from egg to adult, it was believed that some of the naupliar stages were *C. bicuspidatus*. The greatest percent of the nauplii, however, must have been *C. vernalis*. Since *C. vernalis* passed its peak adult population in mid-July, it is reasonable to conclude that numerous *C. vernalis* nauplii should be present in early August. Pennak (1949) noted that the peak of abundance of copepodids and adults were usually in the same month for *C. bicuspidatus* and that the nauplii abundance

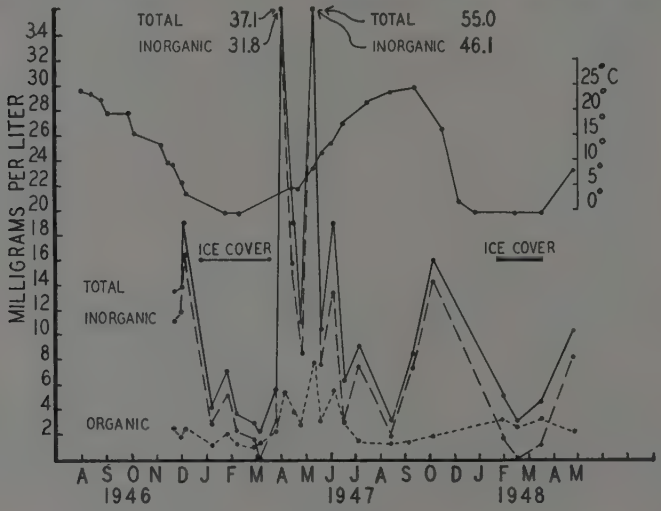

FIGURE 6. Seasonal variations in seston and temperature.

peaks preceded the adult peaks by one or two months. The writer believes this is true for *C. bicuspidatus* in western Lake Erie, but the peaks of abundance for *C. vernalis* adults and nauplii are almost simultaneous since they have such a high reproductive capacity and short life cycle.

Seston. The seasonal occurrence of plankton has been studied in many lakes, but there is very little information on seasonal variations in abundance of seston. Some investigators have estimated seston production on a single or at most a few surface samples. More extensive seston studies have been made on natural water by Birge and Juday (1934), Chandler (1942), and Pennak (1949). Birge and Juday (1934) made summer determinations on 529 Wisconsin lakes, and they found the mean organic seston to be 1.36 mg per liter. Pennak (1949) made year-round organic seston determinations on seven Colorado reservoir lakes and found the following mean annual organic to be: 1.19; 1.74; 1.78; 1.91; 2.35; 4.66; and 13.64. Chandler (1942) working year-round on western Lake Erie stated, "The organic component of this suspended matter varied from a maximum of 4 mgs. per liter in November and December, 1949, to a minimum of 0.2 mgs. per liter in January, 1940."

In this study seston samples were taken at least once each month from November, 1946, to April, 1948 (fig. 6). The writer believes that the points on the organic seston curve of figure 6 are representative of the *standing crop* (Clarke, 1946) of plankton in western Lake Erie. The total seston varied from 2.2 mg per liter on March 18, 1947, to 55.0 mg per liter on May 9, 1947. The mean annual total seston was 12.12 mg per liter. The inorganic seston varied from 0.5 mg per liter on February 16, 1948, to 46.1 mg per liter on May 9, 1951. The mean annual inorganic seston was 9.3 mg per liter, which accounts for most of the total seston. The organic seston, which is indicative of the standing crop, varied from 1.2 mg per liter on January 11, 1947, to 7.9 mg per liter on May 9, 1947. The mean annual standing crop or amount of organic seston was 2.8 mg per liter. All of the above data agree with the findings of Chandler (1942).

It has been assumed by many investigators that the plankton constitute most of the seston. This is a valid assumption excepting in instances when windstorms resuspend bottom materials containing organic matter. If one examines figures 2, 3, 4, 5 carefully, it soon becomes evident that on April 4, when the organic matter measured 5.3 mg per liter, *Cyclops bicuspidatus* was present only in restricted numbers. From other data collected, but not treated in this paper, it is known that *C. bicuspidatus* constituted nearly all of the zooplankton population and that the phytoplankton population was very low. Apparently the increase in both organic and inorganic seston was due to wind action resuspending bottom materials. On May 9, when zooplankton and phytoplankton populations were relatively low, inorganic and organic seston were most abundant. Resuspended bottom materials accounted for high percentage of this seston (Andrews, 1948). At other times during this study, the organic seston resulted primarily from plankton.

CONCLUSIONS

The writer has reached the following conclusions: (1) that frequent representative samples must be taken the year-round, if standing crops, seasonal abundance and other population dynamics are to be ascertained; (2) that organic seston is a good index to standing crop of plankton, excepting during periods when wind has resuspended bottom materials; (3) that in western Lake Erie, *C. bicuspidatus* is a cold water monocyclic copepod while *C. vernalis* and *Mesocyclops leuckarti* are relatively warm water forms that are monocyclic or dicyclic.

SUMMARY

1. Seasonal variations in relative abundance of adult male and female *Cyclops vernalis* Fischer, *Cyclops bicuspidatus* Claus, and *Mesocyclops leuckarti* (Claus) from July 29, 1946, to April 24, 1948, are presented.

2. *Cyclops vernalis* was found to be a spring, summer and fall form, reaching maximum abundance in late June or early July when the water temperature was about 20° C. The females outnumbered the males on the average of 9.5 to one.

3. *Cyclops bicuspidatus* was found to be a winter and early spring form, reaching maximum abundance in late May or early June, when the water temperature was about 15° C. The females outnumbered the males on the average of 3.3 to one.

4. *Mesocyclops leuckarti* was found to be an early summer and fall form, reaching a maximum abundance in August or September when the water temperature was about 22° C. The females outnumbered the males on the average of 2.2 to one.

5. Seasonal variations in mean water temperatures are presented, and the durations of ice covers are indicated.

6. Seasonal variations in inorganic and organic seston are presented. Organic seston, when determinations are made monthly throughout the year, is a good index to standing plankton crop, except when bottom materials have been resuspended.

7. It is concluded that meaningful population dynamics can be ascertained only through analyzing results obtained from year-round representative samples taken at frequent intervals.

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The Elk of North America. *Olaus J. Murie.* The Stackpole Co. and Wildlife Management Institute. Harrisburg, Pa., and Washington, D. C. 1951. 376 pp. $6.50.

An interesting and authentic account of the biology of the American Wapiti aimed primarily for the student of wildlife management, it is written in such a style that it is easy reading for the layman as well as for the biologist. The author spent several years studying the Elk of North America with the result that he is now our foremost authority on this subject. This book is highly recommended for general reading, but is of especial importance to the wildlife student and vertebrate zoologist. As a zoology reference in life history studies, it ranks along with Einarsen's study of the Prong-horn Antelope.

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EFFECTS OF CERTAIN INORGANIC IONS ON CORN LEAF CATALASE

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Smirnow and Alissowa (1924) reported the relative activity of catalase extracted in salt solutions from wheat seeds as compared with water extracts and found that with M/20 sodium salts the reduction in catalase activity was $NO_3 > Cl > B_2O_4 > SO_4$, and that with M/20 chloride salts the reduction was $Mn > Ca > Mg > NH_4 > K > Li > Na$. These results do not give a direct measure of the effect of various salts on catalase inhibition. Instead, the results seem to be a measure of the effect of the salt on extractability of catalase in addition to the salt's inhibiting influence on the activity of the extracted catalase. They measured the catalase activity by adding 5 ml 1% H_2O_2 to the seed extract, letting it stand 30 minutes, adding 3 ml 10% H_2SO_4 and then measuring the undecomposed H_2O_2 by titrating with 0.1 N $KMnO_4$.

Charmandarjan and Tjutjunnikowa (1930) likewise reported on the relative activity of catalase extracted from germinating barley seeds. They worked with water extracts to which various salt solutions were added and with salt solution extracts to which water was added. Water extracts to which an equal volume of M/20 sodium salt solution was added showed following inhibition sequence $NO_3 > Cl > SO_4$, and $Zn > Mn > Ca > Mg > NH_4 > Na$ for water extracts to which an equal volume of M/20 chloride salt solution was added. Catalase measurements by these investigators were made by titrating excess H_2O_2 with 0.1 N $KMnO_4$.

Santesson (1923) examined the effects of several anions and gave the succession in the following way on a rising scale: $SO_4 < HPO_4 < F < B_4O_7 < CO_3 < Br < I < Cl < NO_3 < ClO_3$. Michaelis and Pechstein (1913) working with blood catalase found that, at high hydrogen ion concentrations, low anion concentrations were sufficient to provoke a certain inhibition, and high anion concentrations were necessary to produce the same inhibition at low hydrogen ion concentration, and that sulfate ions inhibit only to a relatively slight extent, whereas chloride and especially acetate and nitrate are strong inhibitors. Agner and Thoerell (1946) stated that much of the supposed pH effect was really due to the inhibition by anions which increased with decreasing pH.

Boas (1934) in experiments with potato tuber tissue reported greatest inhibition of catalase by SCN and least by SO_4. Using chloride salts, the order of inhibition from greatest to least was as follows: $Ca > Mg > K > Li$. Boas measured the amount of O_2 given off in a gas burette by cork borer made cylinders of potato tubers of equal weight placed in 30 ml 1% H_2O_2.

Favre (1911) studying the activity of catalase in blood gave data which showed that chlorides inhibited more than sulfates and that Mn and Mg cations were more inhibitory than Na and K. He had the excess H_2O_2 react with iodide to form iodine, and then measured the amount of iodine formed by titrating with $KMnO_4$.

Since catalase exists in chloroplasts associated with chlorophyll, there is a possibility that catalase may be involved in photosynthesis (Yakushiji, 1933). Only very limited studies have been made on the direct and immediate effects of solutes and catalyst poisons on leaf catalase. For this reason it was deemed desirable to investigate this problem further. On the basis of toxicity effect of various solutes and catalyst poisons it may eventually be possible to decide the

question whether catalase is concerned with photosynthesis. A subsequent paper will describe the effects of catalyst poisons.

METHODS AND MATERIALS

The method described previously (Eyster, 1950) was used for the quantitative determinations of catalase activity. A 1 g sample of fresh leaves from green corn seedlings, two to four weeks old, usually grown in the greenhouse was macerated and placed in a small flask. Distilled water was added to make the total volume of the suspended leaf tissue 25 ml. Usually two control measurements of the catalase were obtained by placing 2 ml of suspension in one arm of a catalase tube for each determination. This brought the total volume of the macerated corn leaf tissue down to 21 ml, and then to make the volume 20 ml,

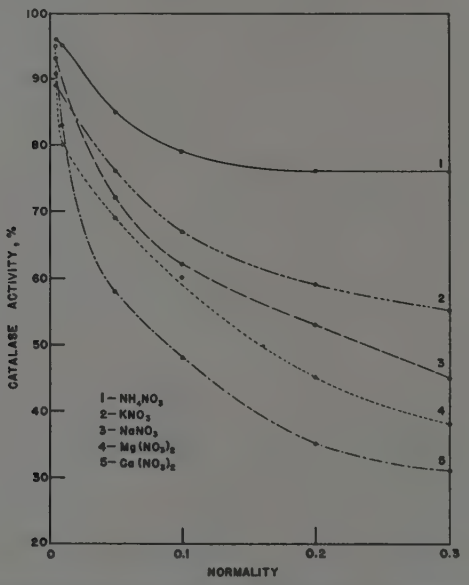

FIGURE 1. Varying effects of different nitrates on the activity of catalase in macerated corn leaves. Catalase activity is expressed in percent on the basis of 100% for the control measurement.

1 ml was drawn off and discarded. To test the influence of a chemical compound on catalase activity, a weighed amount of the compound was added to the 20 ml to make a definite known concentration. A magnetic stirrer aided in getting the compound quickly dissolved and thoroughly mixed. Measurement of catalase activity was resumed after the chemical compound was added and determinations were continued until two close measurements (within 0.2 ml) were obtained. The last two measurements were then averaged and compared with the average of the two control measurements on a percentage basis. The computations were done with the assumption that the control average represented 100%.

Landon (1934) states: "It is well known that the activity of most catalase preparations made from plant tissues declines more or less rapidly from the time of preparation." To determine what effect standing has on catalase activity corn

leaf preparations were tested immediately and after 4½ hours of standing. Measurements made during early stages of this study were exactly the same as measurements made near the end. Both showed a decline in catalase activity

TABLE 1

Solute effect on activity of catalase in macerated corn leaves. Catalase value is expressed as milliliters of O_2 in a 5-minute interval.

Solute	Concentration	Catalase Activity A Without Solute	Catalase Activity B With Solute	B/A
		ml.	ml.	%
NH_4NO_3	0.005 N	10.56	10.12	96
	0.01 N	7.61	7.26	95
	0.05 N	6.50	5.53	85
	0.1 N	11.13	8.77	79
	0.2 N	11.40	8.42	74
	0.3 N	8.86	6.54	74
KNO_3	0.01 N	9.72	8.36	86
	0.05 N	7.46	5.65	76
	0.05 N	11.06	8.37	76
	0.1 N	9.56	6.40	67
	0.2 N	9.16	5.32	58
	0.3 N	10.07	5.52	55
$NaNO_3$	0.001 N	10.96	10.80	99
	0.005 N	9.98	9.26	93
	0.01 N	9.86	8.22	83
	0.05 N	10.90	7.87	72
	0.1 N	9.18	5.70	62
	0.2 N	10.07	5.36	53
	0.3 N	11.20	5.00	45
$Mg(NO_3)_2.6H_2O$	0.005 N	9.10	8.67	95
	0.01 N	9.03	7.24	80
	0.05 N	9.93	6.88	69
	0.1 N	10.52	6.34	60
	0.2 N	11.61	5.26	45
	0.3 N	8.74	3.36	38
$Ca(NO_3)_2.4H_2O$	0.005 N	11.36	10.35	91
	0.01 N	8.48	7.06	83
	0.05 N	8.46	4.94	58
	0.1 N	9.85	4.68	48
	0.2 N	10.34	3.61	35
	0.3 N	10.92	3.41	31
$NaNO_2$	0.0001 M	11.62	10.70	92
	0.001 M	11.56	5.63	49
	0.01 M	12.00	1.66	14
	0.1 M	6.66	0.32	5
$CaCl_2.2H_2O$	0.1 N	11.12	9.72	87
NaCl	0.1 N	11.22	10.26	92
	0.3 N	10.28	8.78	85
	0.5 N	10.70	9.17	86
$Na_2HPO_4.7H_2O$	0.3 N	11.03	10.72	97
Na_2SO_4	0.1 N	5.74	5.90	103
$NaC_2H_3O_2.3H_2O$	0.3 M	8.00	7.80	98

to only 95% of what it was in the fresh preparations. Most of the experiments were completed in an hour and some may have required as much as three hours to attain an equilibrium, but none of the experiments required 4½ hours. It is assumed then that standing did not reduce the activity more than 5%, and that any reduction to 90% or less of its original activity might be significant.

RESULTS AND DISCUSSION

The solute effects on catalase activity are given in table 1. Nitrate ions had a marked effect and chloride ions had a slight effect, whereas sulfate and phosphate ions appeared to have no influence on catalase activity. The cation associated with the nitrate ion had a modifying influence in the order: $NH_4 < K < Na < Mg < Ca$ (fig. 1). The cation associated with chloride showed $Na < Ca$, and it is likely that the cation effect is comparatively the same regardless of the associated anion.

The nitrite ion had a far more depressing effect on catalase activity than the nitrate ion. Sodium nitrite toxicity began at about 0.0001 M as compared with sodium nitrate toxicity which began at about 0.001 M. An inhibiting effect of sodium nitrite on blood catalase was reported by Rotini and Snassel (1933).

SUMMARY

1. Nitrate ions had a marked effect and chloride ions had a slight effect, whereas, under the conditions of the experiments reported, sulfate and phosphate ions appeared to have no influence on catalase activity.

2. The cation associated with the nitrate anion had a modifying influence in the order: $NH_4 < K < Na < Mg < Ca$.

3. $NaNO_3$ was toxic in concentrations down to 0.001 M.

4. Nitrites were even more toxic than nitrates. $NaNO_2$ was toxic in concentrations down to 0.0001 M.

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BIOLOGY OF THE SWEET CLOVER WEEVIL AND NOTES ON THE BIOLOGY OF THE CLOVER ROOT CURCULIO[1, 2]

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Blatchley and Leng (1916) list four species of weevils in the genus *Sitona* which are found in eastern United States, and record two of these as feeding upon clovers: *Sitona hispidula* Fabr. and *Sitona flavescens* Marsham.

A third species of the genus, *Sitona cylindricollis* Fahraeus, the sweet clover weevil, has attracted attention as a major economic pest within the last 20 years. The sweet clover weevil is presumably of European origin and the date of its introduction into North America is far from definite. Munro *et al.* (1949) and Bird (1947) stated that the earliest record for America is 1924. Goble (1937) stated the first record was 1927, although in his opinion, the density of the population in Ontario in 1936 indicated that if the weevil is of European origin, that it must have been in America for at least 20 years.[3] The earliest literature record for the appearance of the weevil in the United States was by Hyslop (1934).

Munro *et al.* stated that the weevil is distributed in North America from Maryland to Nebraska and northward into the provinces of Canada east of the Rocky Mountains. Allard (1864) recorded it from France, Hungary, Austria, and Italy. Jackson (1920) reported it from England, but very erratic and localized. Alimdahanov (1941) and Yakhontov (1935) reported it from the irrigated region of central Asia.

Descriptions of the adult weevil have been provided by Schoenherr (1840) and by Allard (1864). Allard considered *S. nebulosis* Ziegler, *S. micellus* Ziegler, and *S. ulicis* Ulrich as synonyms of *S. cylindricollis* Fahr., but cited no source of the above descriptions and no type locality. Jackson (1920) considered *S. meliloti* Walton as a synonym, although Allard retained it as a separate species.

Biological studies were conducted at The Ohio State University for two summers and one winter, covering the period 1950–51. Field studies were supplemented by laboratory experimentation. Biological studies had previously been conducted in Manitoba by Bird, but no study had been made under climatic conditions approaching those of Ohio.

Laboratory examination of field collections of both adults and larvae revealed that two species of the genus *Sitona* were found in sweet clover plantings. The second species was identified as *S. hispidula* Fabr., the clover root curculio. Larvae of this species represent as much as 50 percent of early spring collections, but averaged less than 10 percent in later collections. Adults are especially abundant in central Ohio in autumn and winter, but apparently migrate to other host plants in the spring. White clover (*T. repens* L.) was observed to be an important host plant in spring and summer. Notes on the biology of the species are therefore included in the present study.

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[1]Part of a dissertation submitted to the Graduate Faculty of The Ohio State University as partial fulfillment of requirements for the degree of Doctor of Philosophy.

[2]Conducted in cooperation with the Department of Agronomy of The Ohio State University and Mr. B. A. App of the U. S. D. A. Legume Seed Research Laboratory, Columbus, Ohio. Helpful suggestions by Dr. R. H. Davidson are appreciated.

[3]Specimens of weevils collected in Ohio in 1904 and previously determined to be *S. cylindricollis* Fabr. have subsequently been determined to be *S. flavescens* Marsham, by the U. S. National Museum. The author sincerely regrets this error.

METHODS

Laboratory temperatures were determined by both hygrothermograph and laboratory thermometer. Field temperatures were determined by laboratory thermometers, for both atmospheric and soil readings.

Field collections of adults were taken with a small aspirator. Throughout the periods when adults are present and active, they may easily be collected by quickly separating the debris from around a plant and closely observing the soil surface. The adults feign death for a short period and then scurry for the nearest shelter. Regular periodic collections were taken during hibernation by bringing debris and soil into the laboratory and heating thoroughly. The weevils are quickly spotted and collected as they move from the heated material.

Larval collections were obtained by sifting the soil taken from around plants. The very small larvae of the first two instars may be more easily collected by placing a removable bottom of 16 mesh screening over the larger mesh of the soil sifter. Some larvae may be killed, but the reduced volume of soil is easier to handle. The sifted soil was placed on dark paper under adequate illumination, and as it was spread thinly over the surface, the active white larvae were collected. Larger larvae and pupae are quickly spotted in sifted soil and may be easily collected in the field. Larvae and pupae were retained in Peterson's killing solution (1948) for at least 24 hours and transferred into 95 percent ethyl alcohol for storage.

Observation and stock cages for adults were prepared by replacing the domes of two piece mason jar lids with 24 mesh screening. In this manner the cage size could be regulated to the population of adults to be retained. Food and feeding methods are discussed under types of oviposition cages.

Two types of oviposition cages were used in obtaining records from mating pairs of weevils. Pairs were confined to numbered homeopathic vials, each of which was closed with a small square of muslin held securely by a rubber band. Females readily oviposited in this cage, but daily feeding of a trifoliate leaf of clover was necessary, as well as a daily cleaning. It was usually necessary to remove the weevils to temporary quarters for cleaning of the cage. Eggs were removed each day and counted under a binocular microscope.

In 1951 pint mason jars were cut in half, the domes of the two piece lids replaced with disks of 24 mesh screening, and the open end closed with a square of muslin held securely by two rubber bands. Small homeopathic vials were fitted with corks having holes through them made with a No. 1 cork borer. The vials were filled with water, stoppered, and the stems or petioles of clover leaves were pushed through the hole in the cork and into the water. The stems were secured with bits of cellu-cotton, and the feeding unit placed in the cage with a pair of weevils. The cages were placed on a board containing circular holes of identical size to that of the domes of the lids. The board was supported by wooden strips just high enough to clear a Petri dish. As the eggs were deposited they dropped through the screen domes into the dishes and a daily record was made of the number from each dish for each pair. The food supply was changed twice weekly and the cage cleaned once weekly.

Eggs collected from the oviposition cages were placed on moistened filter papers in Petri dishes, and either retained in the laboratory or removed to constant temperature chambers to determine incubation periods.

The sweet clover weevil was successfully reared in the laboratory by potting sweet clover seedlings grown in greenhouse benches, and introducing eggs into the loosened surface of the soil. Immature stages were recovered by the same methods used in the field. Collections were taken at regular intervals. Soil temperatures around potted plants were determined by utilizing thermocouples placed at varying depths within the pot, and at several locations on greenhouse benches.

Pupae collected in the field were brought to the laboratory, placed in moistened

sand in dishes, and observed until adults had emerged. The pupae were less active and survived better if placed in small holes in the sand and stored in darkness.

LIFE HISTORY STUDIES

The weevil has apparently but a single generation per year in North America. Two generations per year are reported in Asia on irrigated lucerne by Alimdzhanov.

The adults enter hibernation quarters as early as September 1, and have not been observed actively feeding after the first killing frost; however, they were observed to move about until late November, and if removed from their hibernation quarters, quickly scurried back into a sheltered niche.

Hibernating adults are found in the upper inch of soil or against the soil surface under debris. The better drained areas of the field are selected, while wet areas and extremely porous materials are avoided.

Spring activity begins as soon as the sweet clover has begun growth, and at ground level temperatures near 60° F. Adults were observed actively feeding as early as March 2, and were congregated around plants having new shoots, or feeding on buds and tender sprouts on the tap root; however, most were feeding above ground.

Intensive mating activity was observed as early as March 10, becomes more pronounced as the temperature rises, and continues throughout the natural life of the adult. Males often quickly grasp bits of soil or debris that are in motion, as well as other males, but quickly release them and continue an aggressive search for females. Pairs were observed in copulae for as long as fifteen minutes, and quite often the uncoupled male is carried by the female while she oviposits or feeds.

Spring migration is accomplished by flight as well as by crawling over the soil surface. Flight was not observed until after the temperature had approached 75° F, and was usually very evident just ahead of a storm. Intensive migration by flight persists for approximately three weeks, usually beginning in late April.

Field collection records show that the overwintering adult population is greatly reduced by June 1, or shortly after, although some adults lived as late as November under laboratory conditions.

The spring preoviposition period is as short as one week. Laboratory oviposition was obtained as early as March 12; field oviposition observed as early as March 23, and it is believed that eggs were deposited even prior to this date. Females were observed to oviposit while feeding or resting, and showed no tendency to place eggs in any niche. Some eggs may lodge on objects above ground, but most fall to the soil surface around plants and are hidden in soil crevices or under debris. Freshly deposited eggs may be observed in the field by carefully examining the soil surface under the plant in late afternoon. The white color of the eggs is in direct contrast to the dark color of the soil.

Dyar's Law (Comstock, 1940) states that a linear measurement in successive instars of larvae is in a geometric progression. Head capsule measurements were taken from more than 1600 larvae from both field and laboratory reared material. Molting larvae were observed whose head capsules were near 0.83, 0.53, and 0.33 mm. The average ratio between any two consecutive measurements of the above series is 0.62. This ratio indicates that another molt (the first) must occur near 0.20 mm. The head capsule of the newly hatched larva measures from 0.14 to 0.16 mm. It is therefore concluded that the larvae pass through four instars and that Dyar's Law will serve to determine the approximate instar of a larva. Similar data were obtained by Bird.

In 1951 larvae were first recovered in the field on May 6. Weekly collections of immature stages were taken from yellow sweet clover plantings through June 30, and measurements recorded. Larvae and pupae were recovered from around plants of white varieties as late as the middle of July. The total period over which larvae may be recovered is influenced by the host plant, the ecological

niche, and the soil. Plants growing in heavy soils and in protected situations tend to support a larval population somewhat later than those in open situations and lighter soils.

Two seasons of field sifting have shown that there is a vertical migration of the larvae within the soil. The younger larvae are usually below three inches and the more mature larvae in the upper three inches of soil. Bird observed this migration in Manitoba and presented his findings in tabular form.

The field records (table 1) indicate that the larval instars require from 30 to 40 days under Ohio conditions. The same period is reported in central Asia by Alimdzhanov. Bird reports that the last two instars require 30 days in Manitoba.

Pupae are found in the upper inch of soil, within a small, lined chamber, just large enough to permit unhampered movement. The larval exuvium may be found near the caudal end of the pupa. The preparation of this chamber was not observed. Marshall and Wilbur (1934) reported that *S. hispidula* requires 4 days to complete the pupation chamber and that liquid is added to the soil from the mouth which aids in preventing soil from crumbling. The duration of the pupal stage varies from 7 to 12 days.

TABLE 1

Seasonal Development (1951) of S. cylindricollis *Fahr.*

Date	Head Capsule Measurements (mm) and Number of Larvae in Each Range							Pupae	Adults
	0.2–0.3	0.3–0.4	0.4–0.5	0.5–0.6	0.6–0.7	0.7–0.8	0.8–0.9		
6 May	4	5	52	37	23				
13 May	14	22	30	23	1				
20 May			1	17	1	13	7		
27 May			6	4	3	17	22		
3 June				1	2	12	19	15	
10 June					1	1	7	35	6
17 June					1		6	36	4
24 June							1	2	1
30 June							0	0	0

The new generation of adults remains within the pupation chamber at least 24 and often 48 hours. It was observed that the emergence from the soil begins about dark and is practically completed by 10 P.M. The new generation emerged the latter half of June in both 1950 and 1951. The adults feed voraciously, migrate to new seedlings, and remain active throughout the summer, seeking hibernation quarters with the arrival of cool weather in September or October. Adults have never been observed in flight during summer and it is believed that summer and autumn migration is accomplished entirely by cursorial means.

In the laboratory both species of weevils were observed to sluggishly crawl at temperatures as low as 5° C, but temperatures approaching 60° F were necessary to induce intensive activity.

Caged adults of the sweet clover weevil taken from hibernation fed readily on sweet clover leaves, did not attempt to mate until February, and failed to oviposit before March under laboratory conditions. They were fed young seedlings, new growth from second year plants, growth from mature seedlings, and subjected to varied periods of exposure to low temperatures. No combinations of food or temperature that were used resulted in oviposition.

Laboratory oviposition records were obtained from 20 pairs in 1950 and 25 pairs in 1951 (table 2). Individual oviposition records show that adults are erratic in oviposition habits. Most females produce heavily for a few days, followed by a period of little or no oviposition. The average daily production ranged from 40 to 70 eggs. Approximately 85 percent of the total oviposition was completed by late April. Records for the two years indicate that the maximum number of completely developed eggs deposited by a female ranges from 1600 to 1800. The highest individual records included 671 infertile and incompletely developed eggs in 1950 and at least 876 of the same type in 1951. Infertile and incompletely developed eggs were more evident as the season progressed and especially prominent just prior to death of the female.

Freshly oviposited eggs are pearly white, or tinged with yellow, devoid of reticulations, very slightly oval in shape, and measure approximately 0.33 by 0.40 mm. Eggs turn a jet black color within 24 hours if held at 60° F or above, but may not darken until 48 hours at lower temperatures. A small percentage of eggs do not develop the dark coloration and may or may not be fertile.

Eggs required an incubation period of 7 days at 80° F, 8 to 10 days at 65° F, 30 days at 54° F, failed to hatch after 50 days at 41° F, but hatched in normal time if removed to higher temperatures. Eggs were observed to hatch if moisture was removed from around them after the first few days, but the eclosion mortality of larvae was very high. Eggs hatched in the usual time in vials of water and the immersed larvae were observed to live for 72 hours or longer.

TABLE 2

Oviposition Records of S. cylindricollis *Fahr.*

Year	Number pairs	Daily* max.	Monthly* max.	Max in month of	Season* max.	Season ave.
1950	20	106	1135	April	2403	780.4
1951	25	86	1080	April	2506	1041.4

*Individual records.

The newly eclosed larva of the sweet clover weevil is pale white, or tinged with yellow along the path of the digestive tract. Larvae range in length from 0.62 to 1 mm; average 0.20 mm in width; the head is prominent, subtriangular to cordate in shape, and hyaline to light chocolate color, the side margins and posterior emargination are more deeply pigmented; it is near 0.16 mm in width and 0.20 mm in length; the body tapers from the thoracic segments, and each segment bears long pale hairs. The mandible is trilobed, the basal lobe is not especially distinct from the distal lobes.

The mature larva of the sweet clover weevil is white or tinged with yellow along the digestive tract, apodous, slightly curved, averaging 4.7 mm in length, 1.8 mm in thickness, and the long hairs of the body segments were more evident near the caudal end; the head capsule is near 1 mm in length and 0.8 mm in width; the mandible is mitten-shaped, trilobed, the lobes being subequal in length. The mature larvae and head capsule are figured in detail by Peterson (1951).

The characteristic manner of larval locomotion was described in detail by Marshall and Wilbur (1934). The description was based on larvae of the clover root curculio, but adequately applies to larvae of the sweet clover weevil.

The pupae are clear white or tinged with yellow on the dorsal abdominal area; they range from 4.7 to 5.8 mm in length, average 5.3; they range in width from 1.2 to 1.4 mm, average 1.3; each abdominal segment bears a row of hairs, usually

quite conspicuous; the posterior margins of the terminal segment bear two prominent recurved spines, pigmented on their apical halves; each spine bears two prominent, spinules whose apices reach approximately one half the distance to the apex of the spine; the penultimate segment bears two prominent, short, dorsolateral spines, which are usually deeply pigmented and slightly longer than the tubercle which bears them. Young pupae are a clear white, but become tinged with yellow on the dorsum of the abdomen by the second day. The eyes and apices of the mandibles are distinctly reddish by the fourth or fifth day.

The life history was completed in 45 to 70 days. The incubation period required 7 to 10 days, the larval instars 29 to 45 days, and the pupal period 7 to 12 days. The first larval instar required less than 5 days, the second and third about one week each, and the fourth about 12 days. Behavior patterns observed in the field were also observed under laboratory conditions.

The recorded host plants of the sweet clover weevil in North America include alsike clover (*T. hybridum* L.), black medic (*M. lupulina* L.), alfalfa (*M. sativa* L.), and sweet clover (*Melilotus* spp.). Adults were observed to feed very sparingly on alsike clover, and were observed feeding on alfalfa but once. Adults fed on alsike, alfalfa, and black medic when forced by starvation measures under laboratory conditions, but failed to feed on red or white clovers.

Larvae were not recovered from any host plant other than sweet clover in either field or laboratory. They were not observed to destroy or inhibit nodule formation, even when a dense population was present. However, they have been reported to severely destroy nodules on lucerne in central Asia by Yakhontov.

NOTES ON THE CLOVER ROOT CURCULIO

Caged adults of this species, taken from hibernation quarters, fed readily on both sweet and red clover leaves, showed a distinct tendency to mate, and usually oviposited within 4 hours after being brought into the laboratory. Females produced fertile eggs in autumn, winter and spring. Few eggs were obtained from females after the first 24 hours in the laboratory.

The only overwintering stage observed in Ohio was the adult, but it is suspected that the species may also overwinter as egg or larva.

Field and laboratory observations indicate that this species is active at temperatures slightly below those required by the sweet clover weevil, and that it is also active somewhat later in autumn and earlier in spring.

The peak of emergence for the spring generation of adults was observed to slightly precede the peak for the sweet clover weevil, but larvae may be recovered from white clover much later than larvae of the sweet clover weevil.

The eggs of the clover root curculio are so similar to those of the sweet clover weevil that no constant differences or characteristics were found for separating the two species. The eggs required an incubation period of 11 to 14 days,tending to approach the latter figure, when managed in the same manner as eggs of the sweet clover weevil.

The newly hatched larvae of the clover root curculio closely follow the description by Wildermuth (1910), except as to measurements. When hatched under laboratory conditions the larvae has a distinctly cordate-shaped head capsule, averaging 0.18 mm in width and 0.23 mm in length. Larvae averaged 0.96 mm in length and 0.28 mm in width. The body is distinctly more stout than the body of the sweet clover weevil. The head capsule is flattened at the cheeks and often slightly acuminate. The mandible is distinctly trilobed, with the basal lobe shorter than the distal lobes.

The mature larvae closely resemble those of the sweet clover weevil but are characterized by a distinct purplish cast when freshly exposed, their smaller size, and a more curved body. After killing in Peterson's solution the body has a more yellowish cast and is more curved than larvae of the sweet clover weevil. The

head capsule is usually flattened at the cheeks and often slightly acuminate. The mandible is distinctly trilobed, mitten-shaped, and with the basal lobe usually distinctly separated from and shorter than the distal lobes. Wildermuth has given further details.

The pupa is figured by Wildermuth. They are usually smaller than those of the sweet clover weevil, averaging 4.3 mm in length and 1.2 mm in width. Wildermuth states that the terminal spines bear one small secondary spine near the base. All specimens examined in Ohio bear two very small spinules near the base of each terminal spine, which are much smaller and shorter than those of the sweet clover weevil. The dorsolateral spines of the penultimate segment are not pronounced and seldom longer than the tubercle which bears them.

The two favored host plants were observed to be white and alsike clovers, although in some instances, plantings of sweet clover supported a dense population of this species. The species has been reported from a large number of leguminous hosts and also as severely damaging legume root systems while in the larval stage.

Larvae of the species were found to destroy the nodules on sweet clover plants and were observed feeding in lesions on the tap root.

NATURAL ENEMIES OF BOTH SPECIES

Adults of both species were attacked by one or more species of fungi during the hibernation period. Diseased specimens were sent to the U. S. National Museum for identification. The Division of Mycology and Disease Survey reports that the fungus failed to properly sporulate, but was probably near *Sporotrichum* spp. The effectiveness of the agent in reducing populations was observed to be very erratic and localized.

Bird reports that *Beauvaria bassiana* (Bals.) is an important pathogen of the sweet clover weevil in Manitoba, and that *Fusarium scirpi* var. *acuminatum* (Ell. & Ec.) was also isolated from diseased weevils. He also states that Allison has reported a new species of *Hirsutella* attacking the weevil in Wisconsin. Steinhaus (1949) stated that *Mycetosporidium jacksonae* Tate is parasitic on *Sitona* weevils.

No insect parasites were recovered from the adults in Ohio and no predators were observed. Munro and Post (1948) reported the importation of two parasites from France to combat the sweet clover weevil. Information regarding their establishment has been given by Munro *et al.* (1949) and by Berry *et al.* (1950). Telford and Munro (1944) reported the plains toad is an important enemy of the sweet clover weevil. Bird reports that he believes that Franklin Gulls feed on the weevil in Manitoba. Wildermuth reports fourteen species of birds that are known to feed upon the clover root curculio.

Diseased larvae were also observed, but were usually not discovered until after killing. The biological agent or agents involved were not determined. Marshall and Wilbur have reported that nematodes of the genus *Diplogaster* attack larvae of the clover root curculio.

Bigger (1941) reported that a specimen of *Stenus* sp. (Staphylinidae) was observed feeding on the eggs of the clover root curculio.

The two weevils are similar in habits and activities and it appears likely that most natural enemies of one species are also important enemies of the other. Additional detailed information is cited in the references presented in the selected bibliography.

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THE ROLE OF THE OHIO ACADEMY OF SCIENCE

The December 28, 1952, issue of the Academy Conference Directory provides pertinent data on the 38 academies affiliated with the AAAS. This publication reveals that the Ohio Academy of Science is second in size among the academies. In addition, only one of the academies publishes a journal as frequently as our academy publishes the Ohio Journal of Science.

Ohio surpasses the state which has the largest academy not only in population and wealth but in the number of colleges and universities in the state. It would therefore be very easy for the Ohio Academy of Science to take its rightful first place among the academies of the nation. Each member of the academy has many acquaintances who are potential academy members. Many of them would be honored by your personal invitation to join the Ohio Academy of Science.

Many of us, especially the older academy members, are apt to think of the academy as just one of those institutions that we have grown up with. We do not often have a 50th anniversary during which we take stock of our accomplishments and during which the scientists of the nation pay tribute to one of the great academies of the nation. The truth is, however, that the academy is a living, growing, energetic force at work initiating the spirit of scientific inquiry in the minds of young people in Ohio, renewing it and spurring it on in the minds of high school and college science teachers of the state, improving the teaching of science in the schools of the state, and providing the opportunity for research workers to lay the results of their research, both verbally and in print, before the people of the state, the nation, and the world.

The Ohio Academy of Science is a powerful force in the state of Ohio but it can do more, and can do its work better, if its membership continues to grow. During the past three years, the Ohio Academy of Science has increased in membership by about 50 percent. Let's double our membership of 1,250 in this sesquicentennial year of the state of Ohio!

Enroll a new member:

NEW GENERA AND SPECIES OF CURCULIONIDAE WITH A NEW SPECIES OF ANTHRIBIDAE

(COLEOPTERA)

ELBERT L. SLEEPER

Department of Zoology and Entomology, The Ohio State University, Columbus 10

During my studies of the Rhynchophora I found several undescribed species of Anthribidae and Curculionidae. Two new genera, six new species, and two new subspecies are herewith published with additional notes on other species of Curculionidae.

The Myrmecinae included are part of a study made of that subfamily in partial fulfillment of the requirements for the degree of Master of Science at The Ohio State University.

I am greatly indebted to Professor J. N. Knull, Curator of the Entomological Collection, The Ohio State University, under whose supervision I have worked for several years, and to Dr. D. J. Borror of the same institution for helpful criticism of my work. Sir G. A. K. Marshall has been most helpful in his willingness to compare material with the Champion types in the British Museum of Natural History. I am very grateful to Drs. E. A. Chapin and W. H. Anderson for their kindness and cooperation in making it convenient for me to study material in the Casey and National Museum Collections, and for the loan of material.

To the following workers and institutions I wish to express my gratitude for the loan of material and aid in my work: Dr. R. H. Beamer, University of Kansas; W. J. Brown, Department of Agriculture, Entomological Branch, Ottawa, Canada; Ralph Dury, Cincinnati Museum of Natural History; C. A. Frost, Framingham, Massachusetts; G. Stace Smith, Creston, British Columbia; Dr. E. C. Van Dyke, California Academy of Science; Miss Rose E. Warner, The United States National Museum.

LIST OF ABBREVIATIONS

CAF	C. A. Frost.
(CAF)	C. A. Frost Collection.
(Casey)	Casey Collection.
(CNC)	Canadian National Collection.
DJ & JNK	Dorothy J. and J. N. Knull.
Dury	Charles Dury.
(Dury)	Charles Dury Collection.
ELS	E. L. Sleeper.
(ELS)	E. L. Sleeper Collection.
GFK	G. F. Knowlton.
GSS	G. Stace Smith.
(GSS)	G. Stace Smith Collection.
JDM	J. D. Mitchell.
JNK	J. N. Knull.
LLB	L. L. Buchanan.
MCAS	Museum, California Academy of Science.
MCZ	Museum of Comparative Zoology.
NJ & ELS	Norma J. and E. L. Sleeper.
(OSU)	Entomological Collection, The Ohio State University.
USNM	United States National Museum.
(USNM)	Entomological Collection, United States National Museum.

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ANTHRIBIDAE

Stenocerus knullorum n. sp.

Figure 1

Broadly elliptical, subcylindrical; black, densely clothed with brownish-gray pubescence, variegated with yellow and velvety black.

Rostrum flat, spatulate, rather thin, dilated apically; mesal carina present, lateral carina on each side. Antennal grooves lateral, covered, about midway between eye and base of mandible. Antennae thin, club loose, segments flat, 10 and 11 thin at base, all segments with long bristles.

Head finely, densely punctate, vertex with a long narrow groove. Eyes lateral, slightly oblique, elliptical.

Pronotum conical, widest just before base at curve of the carina. Carina flexed forward at sides, approaching base about middle. Scutellum prominent, yellowish pubescent.

Elytra about half as long again as broad, sides subparallel, arcuate to apex. Disk deeply impressed. Sutural striae occuring only in basal fourth of each elytron. Punctures of striae fine, approximately two diameters apart, deeply impressed.

Beneath black, mottled with yellow. Last ventral segment of female with a prominent tuft of pubescence.

Length 13.0 mm, width 6.3 mm.

Type locality. Hidalgo, Co., Texas IV-7-'50 DJ & JNK. Holotype, female, and allotype in (OSU).

Hosts. Found beneath the loose bark of a standing dead hackberry tree.

It is with great pleasure that I name this species after Professor and Mrs. J. N. Knull who have done much toward increasing our entomological knowledge of the Brownsville, Texas area.

CURCULIONIDAE

Apion longirostre Olivier

This insect has come to the entomologist's attention only recently. It was thought that this weevil entered this country only recently, however, there are several examples of this in the Dury Collection from "Georgia" collected in 1914. I have seen several other examples from near Rome, Georgia collected in 1922. I have seen no recently collected examples from that far south. This weevil is very abundant in Ohio along the southern shores of Lake Erie. Its range extends as far west as St. Louis, Missouri. *A. longirostre* has been destructive to the seeds of hollyhock (*Althea rosea* Cav.) in Northeastern Ohio.

Dietzianus n. gen.

Xanthus Dietz 1891, p. 269. Blatchley 1916, p. 277.

I am suggesting this name to replace *Xanthus* Dietz 1891 [*non* Gristl. 1834]. *Xanthus* Dietz is preoccupied by *Xanthus* Gristl. 1834, Ins.-Doubletten Walworth, 11. Agassiz also misused *Xanthus* for a crustacean genus which should have been *Xantho*. *Xanthus pygmaeus* Dietz is type for genus, *Xanthus liliputanus* Dietz is congeneric.

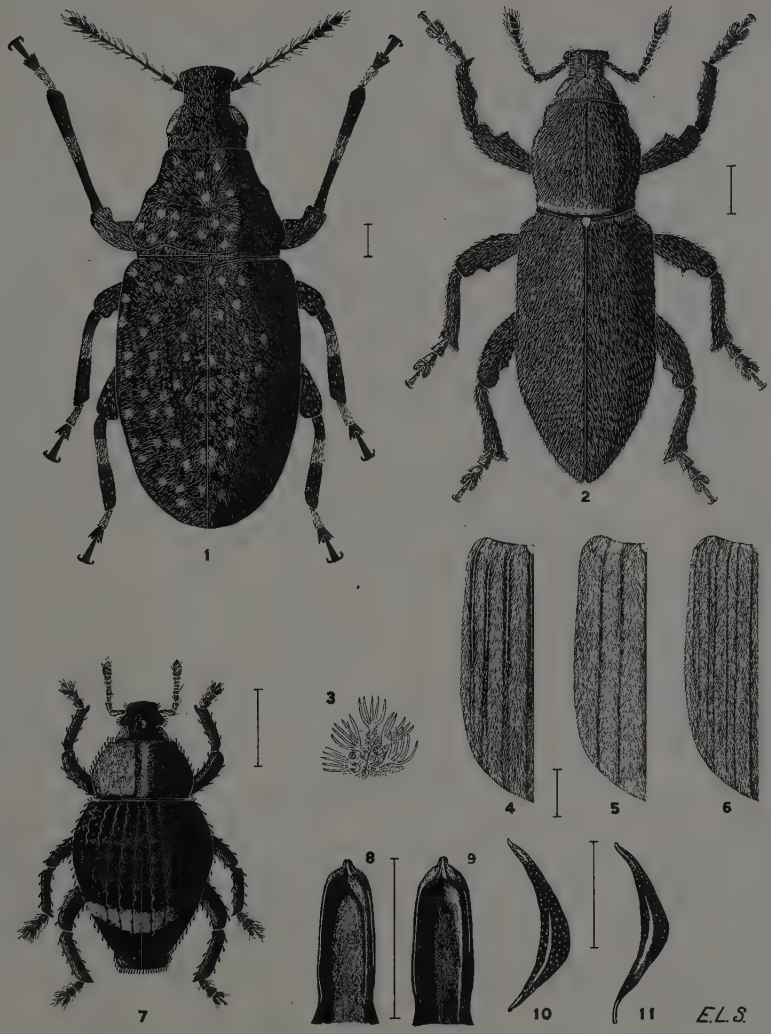
Myrmex lineata knowltoni, n. subsp.

Figures 5, 9, 10

A form of *lineata* is quite common in Utah differing but slightly from the true lineata. I believe it deserves subspecific rank.

Size and form of *lineata lineata* (Pascoe). It differs in more dense pubescence over the entire body. Glabrous intervals are nearly or completely obliterated. The pubescence is much denser on intervals 2, 4, 6, 8, than in *lineata lineata* (Pascoe). There are slight differences in the genitalia (figs. 9, 10). However, none of the above mentioned differences are sufficient to justify giving this specific rank.

Type Locality. Holotype, a male from "Utah, July" in the author's collection. Allotype a female from Lakepoint, Utah VI-8-'45, GFK, in the Entomological Collection, The Ohio State University. Paratypes: two in the author's collection, one from Nelphi, Utah, one from Eureka, Utah; one from Honeyville, Utah V-28-'47, GFK, (OSU); four in (USNM), one from Stockton,



1. *Stenocerus knullorum* n. sp.
2. *Myrmex marshalli* n. sp.
3. Radiate-pectinate setae.
4. Left elytron of *Myrmex lineata lineata* (Pascoe).
5. Left elytron of *Myrmex lineata knowltoni* n. ssp.
6. Left elytron of *Myrmex insignis* (Casey).
7. *Acalles ohioensis* n. sp.
8. Dorsal view of aedeagus of *Myrmex lineata lineata* (Pascoe).
9. Dorsal view of aedeagus of *Myrmex lineata knowltoni* m. ssp.
10. Lateral view of aedeagus of *Myrmex lineata knowltoni* n. ssp.
11. Lateral view of aedeagus of *Myrmex lineata lineata* (Pascoe).

(Line = 1 mm.)

Utah V-10, one from Monroe, Utah VI-30-'26 GFK, one from Salt Lake City, Utah VI-6-'35 GFK, one from Kanarro, Utah VI-18-'35 GFK; a single example in (CNC) from Eureka, Utah VII-16-'20 Tom Spalding; six paratypes in the Casey Collection, three from Stockton, two from Eureka and one labeled "Utah."

Hosts. It has been recorded from "*Chrysothamnus nouseosus* (Pall.)" by GFK at Kanarro, Utah.

This insect was identified and returned to some collections as *Otidocephalus sulcatus* Chitt. However, this was a manuscript name used by Chittenden and is invalid.

Myrmex marshalli n. sp.

Figure 2

Elongate, subcylindrical, black, very densely pubescent with coarse gray appressed setae.

Rostrum about two-thirds as long as pronotum, subcylindrical, with median impunctate, smooth polished line. Antennae dark reddish-brown; scape attaining the eyes; first segment of funicle as long as second, second as long as following two together. Club elongate, oval, feebly pubescent.

Head moderately clothed with gray pubescence, densely, closely, coarsely punctate, slight trace of interocular fovae on some specimens. Eyes finely granulate, rounded, lateral.

Pronotum elongate, subcylindrical, sides feebly arcuate at middle. Surface densely, closely punctate, each puncture bearing a coarse gray seta. At base a few radiate-pectinate scales. Scutellum prominent, densely covered with very fine white setae.

Elytra at base not much wider than pronotum at base, sides subparallel, feebly inflated. Surface densely pubescent except along suture where it is narrowly denuded. Intervals slightly convex, confusedly punctured; striae feebly visible in rubbed specimens.

Beneath very densely clothed with gray setae. Anterior femora with a moderate acute tooth. Anterior tibia strongly sinuate within before middle. Claws plainly toothed.

Length 8.5 mm, width 3 mm.

Type Locality. Presidio, Texas VI-15-'42 J. H. Russell Collector. Holotype female and allotype in the USNM.

There are forty-four paratypes in (USNM), ten paratypes in (ELS), one in (OSU), two in The British Museum, all examples from Presidio, Texas.

Distribution. Examples of this striking species have been taken only in and around Presidio, Texas.

Hosts. "On *Aster spinosus* foliage." Many specimens bear this label.

Closely related to *M. cinera* (Champion) from Mexico, differs in that *cinera* has very sparse subrecumbent setae, [even more sparse than in *uniformis* (Champ.)], its head is more prominent, subquadrate and almost parallel sided, the eyes more convex; pronotum longer and narrower; elytra much dilated behind the middle. *M. marshalli* superficially resembles *uniformis* (Champ.). *M. marshalli* is much larger, more elongate; the pubescence is much denser, coarser; pronotum more elongate, cylindrical, surface much more coarsely, densely, deeply punctate.

It is with great pleasure I dedicate this species to Sir G. A. K. Marshall of the British Museum, a great entomologist and a great help to me in my work.

Myrmex semirufa (Green)

Otidocephalus ruficornis Casey var. *semirufus* Green 1920, p. 197–198.
Myrmex dimidiatus Van Dyke [*non* Dejean] 1930, p. 152. (New synonymy).

After examining a very large series from numerous localities I feel that *semirufa* deserves specific instead of varietal rank. I have compared a paratype of *semirufa* in the USNM with the type of *M. ruficornis* (Casey) and have compared my material with the paratype and the Casey type. Examples of *semirufa* are wholly unlike those of *ruficornis*. Creation of the synonym by Dr. Van Dyke is understandable since the Green variety was not mentioned in the Supplements of the Leng Catalogue or the Coleopterorum Catalogus. I would not have known

of the Green variety if I had not discovered the brief description by accident while browsing through that particular volume of *Entomological News*.

Myrmex algerti n. sp.

Elongate, subcylindrical, convex, black, shining; densely clothed with long erect black and shorter more robust, recumbent white setae; an occasional radiate-pectinate scale over surface of pronotum.

Rostrum polished, as long as pronotum in male and female; bisulcate each side, superior sulcus extending only to middle of rostrum, dorsal line smooth to apical third, apex finely densely punctate. Antennae with first segment three-fourths longer than second, second one-fourth longer than third; club elongate, oval, as long as preceding five segments.

Head coarsely, densely punctate, without frontal fovea, densely punctate between eyes.

Pronotum one-fifth longer than broad, sides strongly arcuate, slightly convex; disk densely, closely, coarsely punctate; surface with abundant erect black setae which are directed forward, and shorter recumbent white setae. Very faint evidence of a median line.

Elytra twice as long as wide, wider at base than base of pronotum, sides subparallel, humeri very prominent not broadly rounded; sutural striae strongly impressed, remainder very feebly so, punctures of series feebly impressed moderately coarse punctures, intervals flat with irregular close-set, minute setiferous punctures, appearing as two rows on some intervals on some specimens.

Beneath moderately pubescent with simple white hairs; shining; finely, closely punctate, more densely at sides. Legs densely clothed with erect black and white setae. Femoral tooth large and triangular; anterior tibiae strongly sinuate within, broadest at middle; strongly bent basally.

Length 5.0 mm, width 1.9 mm.

Type Locality. Holotype female and allotype from San Diego Co., Calif. Holotype in (ELS), allotype in (USNM).

Distribution. All material I have seen representing this species was from San Diego Co. area of California. Six paratypes in (USNM) from Banner, Calif., E. D. Algert Collector. Two paratypes in (ELS) from Banner, Calif.

Hosts. Specimens from Banner, Calif. were reared from mistletoe by E. D. Algert.

Closely allied to *M. arizonica* (Schffr.) for which I believe it has been mistaken. It differs in the flat intervals, more feebly impressed striae and punctures, and strongly sinuate anterior tibiae.

Myrmex gillespiensis n. sp.

Elongate, oval, black, shining, body rather sparsely clothed with long fine erect black hairs and more robust shorter, slightly recurved white hairs.

Rostrum two-thirds length of pronotum; bisulcate laterally; dorsal median line forked in apical half, by a median sulcus; sulci and apex moderately punctate. Antennal club oval, nearly as long as preceding five segments.

Head sparsely, unevenly, distinctly punctate; without frontal fovae.

Pronotum one and one-half times longer than wide, slightly convex, sides feebly arcuate; disk very sparsely, finely punctate except at apex and base where it is more strongly, coarsely punctate.

Elytra twice as long as pronotum, at base one and one-half times wider than base of pronotum; disk with striae feebly impressed, with rows of small very shallow punctures separated by about twice their own diameter. Intervals with a single row of distant, nearly obsolete setiferous punctures.

Beneath shiny, sparsely pubescent with simple white hairs; finely very sparsely punctured. Femora elongate, armed with a broad triangular tooth; tibiae very feebly sinuate within.

Length 3.5 mm, width 1.6 mm.

Type Locality. Gillespie Co., Texas VI-23-'40 DJ & JNK. Unique holotype in (OSU).

Hosts. Nothing is known about the feeding habits of this species.

In form and appearance it resembles *M. texana* (Schffr.) but in vestiture it is more closely allied to *floridana* (Casey).

Micromyrmex n. gen.

Narrowly subcuneate, strongly convex, body nearly glabrous, few erect setae around apex of pronotum, a few long white setae scattered over elytra.

Rostrum of male very short and robust, with a large and very deep dorsal excavation just behind middle, occupying the entire width of rostrum. Rostrum of female more elongate, without deep excavation. Antennal club nearly as long as preceding five segments, strongly annulated. Eyes rather large, moderately prominent, separated by a little less than their own width.

Pronotum obovate, longer than wide, strongly convex, strongly constricted at base. Scutellum distinct, densely clothed with recumbent pubescence.

Elytra oblong-oval, wider than pronotum, strongly convex; disk with feebly impressed striae and punctures.

Prosternum very short in front of anterior coxae which are contiguous; second abdominal segment nearly as long as third and fourth combined, suture between one and two almost obsolete. Legs long, slender; femora completely unarmed, anterior tibiae straight within, not sinuate; tarsal claws divergent, toothed.

Genotype. Otidocephalus poeyi Chevr. *O. cavirostris* Casey is congeneric.

This genus has been set up to remove two widely divergent species of Myrmecini from other members of the genus *Myrmex*.

These species, *poeyi* and *cavirostris*, are much smaller than any *Myrmex:* they lack the femoral tooth that is so characteristic of *Myrmex:* the males have a large dorsal excavation in the rostrum. Though the latter characteristic is purely a sexual one, I believe it, coupled with the other factors mentioned, is sufficient to remove them from the genus *Myrmex* and place them in a new genus.

Casey in 1892 expressed the opinion that these two species should be placed in a separate genus but did not do so.

Oopterinus perforatus iowaensis n. subsp.

Very similar to *O. perforatus perforatus* (Horn) in general form, elytra more oval, robust; punctures of elytral series more deeply impressed, each puncture surrounded by a larger very dark spot. Pubescence of elytra longer.

Length 3.3 mm, width 1.4 mm.

Type Locality. "Iowa" (Northwestern part), ELS, (ELS). Holotype male in (ELS). A paratype in (ELS) from "Mo.".

Distribution. I have seen four examples of this subspecies, all were from Iowa and Missouri. It seems to be confined west of the Mississippi River, while *O. perforatus perforatus* occurs east of the river.

Hosts. It probably breeds in Cynipid galls as does the other subspecies. The holotype was swept from low plants in an oak-hickory woods.

It is easily separable from *O. perforatus perforatus* (Horn) as the elytra are lighter than the rest of body, the darker spots are very prominent, easily visible with the naked eye. At first I thought this to be a teneral, deformed example of *perforatus perforatus*, however, I have since seen the other examples mentioned. None are teneral, all are completely hardened and very constant in form.

Ceutorhynchus erysimi Fabricius

Until recently I believed this small weevil to have entered the United States in the late 1930's. Examination of material in the Dury collection revealed several examples of this from Cincinnati, Ohio collected in 1922.

Acalles ohioensis n. sp.

Figure 7

Oval, robust, black, densely clothed with intermixed recumbent scales and erect clavate setae. Pronotum with intermixed ferruginous and black scales. Basal third of elytra with closely placed ferruginous scales, declivity with a transverse band of white scales, disk with

intermixed black, white, and ferruginous scales. Humeri densely clothed with orange and white scales.

Rostrum robust, nearly as long as pronotum, swollen at base, expanded laterally covering scrobes, sculpture concealed by vestiture. Antennae reddish brown, densely pubescent.

Head finely, densely punctate, sculpture concealed by scales, with a deep puncture between the eyes. Eyes elliptical, lateral, strongly granulated.

Pronotum wider than long, subparallel in basal two-thirds then narrowing to apex; coarsely, deeply, densely punctate; with a median deep distinct channel.

Elytra scarcely wider at base than base of pronotum, widest before middle. Striae distinct, punctures elongate, coarse, shallow, each bearing a scale; the intervals convex.

Beneath densely clothed with orange, brown, black and white recumbent scales. Femora densely, coarsely foveate-punctate. Claws minute, connate, not visible from above, moderately pubescent.

Length 3.0 mm, width 1.7 mm.

Type Locality. Delaware Co., Ohio III-24-'50 NJ & ELS. Holotype a male, allotype, Delaware Co., Ohio III-24-'50 NJ & ELS, in (ELS). Three paratypes in (ELS), one from Delaware Co., Ohio III-24-'50 NJ & ELS, two from Hamilton Co., Ohio V-2 and IX-'22. A paratype in (OSU) Hamilton Co., Ohio VI-6. A paratype in (USNM) Hamilton Co., Ohio V-10. One paratype in MCAS Columbia, Mo: April 1907 (Blaisdell Collection).

Distribution. I thought this species to occur only in two areas in Ohio until recently on a visit to MCAS I saw the single example mentioned above from Missouri. It probably occurs throughout the most of Eastern United States.

Hosts. I have taken this by sifting woodland litter.

This is closely related to *A. pectoralis* Leconte and *A. ventrosus* Leconte, but has the mesosternum very deeply sulcate. *A. ohioensis* is apterous, no wings being present and the elytra fused along the suture.

Rhyncolus stacesmithi n. sp.

Elongate, cylindrical, dark reddish brown, rostrum, antennae, head, pronotum and legs slightly paler than elytra which are almost piceous.

Rostrum as short as *pallens* Casey, sides subparallel, dorsum with a shallow median depression; moderately, densely, finely punctate throughout. Antennae seven segmented, similar in both sexes (not stouter in male than female as in some species).

Head sparsely finely punctate between and above eyes, area bordering apical margin of pronotum very finely sparsely punctate, laterally impunctate. Males with a shallow fovae between the eyes. Eyes strongly convex.

Pronotum slightly broader than long, widest at middle, sides feebly arcuate, apical constriction strong, traceable completely across dorsum, dorsal surface with small fairly dense punctures (separated by their own diameter), no trace of an impunctate median line or smooth median area. Area between punctures feebly alutaceous.

Elytra slightly wider and about twice as long (in male, in female more than twice as long) as pronotum, striae with regular rows of close, deep punctures (about their own diameter apart), intervals convex, more strongly so at declivity. Each puncture with a short, pale, recumbent seta.

Beneath with densely placed small setiferous punctures. No indication of a flat median area or a patch of pubescence on first abdominal sternite of male. First sternite convex in male and female. Last sternite of female with a shallow rounded depression, of male slightly convex.

Length 2.8 mm, width 0.9 mm.

Type Locality. Creston, British Columbia V-25-'47 G. Stace Smith Collr. Holotype male and allotype in (ELS). Twenty-six paratypes, ten in (ELS), remainder in (GSS).

Distribution. (Paratypes) Creston, B. C. V-25-'47 GSS (9), VI-19-'50 GSS (5), IV-9-'50 GSS (1); Wynndel, B. C. GSS (1) (GSS).

Creston, B. C. V-25-'47 GSS (1), VII-19-'50 GSS (1), VI-7-'48 GSS (8) (ELS).

Hosts. All material examined was taken from *Populus* spp.

Nearest *pallens* Csy. but differs in many ways as follows: *stacesmithi* has head less densely punctate; pronotum more sparsely punctate, without trace of a smooth median line; elytral striae and strial punctures deeply impressed, intervals convex instead of nearly flat, elytra darker, than pronotum.

I compared *stacesmithi* with type material of most of the species of this genus that occur in North America, and with specimens indicated by Mr. L. L. Buchanan to be authentic of the remaining species. It is very unlike any of them.

Hormops abducens Leconte

Previously this has been recorded only as far north as Plummer's Island, Maryland. A single example was collected near Fort Ancient in Warren Co., Ohio by the author. It was found while beating a tangled mass of vines that contained an abandoned squirrel nest. The single example mentioned is in (ELS). It was compared with many examples from Florida in the USNM and was found to be the same. This record greatly extends the known range of this once rare weevil.

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FLORA OF OHIO

A preliminary and tentative list of the woody plants of Ohio has been prepared with the hope of stimulating collecting so that our distribution records may be made more complete before distribution maps are made next winter. Counties for which specimens are recorded are given for each species. This list will be made available to anyone who will undertake local collecting to fill the gaps in distribution. It may be obtained from Dr. J. Arthur Herrick, Kent State University, Kent, Ohio. Please send 7 (seven) cents in stamps to cover expense of mailing.

The "Woody Plants of Ohio" is one unit of the proposed "Flora of Ohio," a project sponsored by the Ohio Academy of Science through its Ohio Flora Committee. For further information, see note in the January, 1952, issue of this Journal.

SOME NOTES ON THE EVANIIDAE AS HOUSEHOLD PESTS AND AS A FACTOR IN THE CONTROL OF ROACHES

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The Evaniidae, or ensign wasps, constitute a family of Hymenoptera represented by a relatively small number of species, which as far as is known are parasitic during their immature stages in the egg capsules of cockroaches. These parasites are thus a factor in the natural control of these pests, and the presence of the parasites in a building will usually denote the presence of cockroaches. The adult Evaniidae are medium sized black or reddish black wasps that are readily distinguished by the shape of the abdomen, which is modified so that it resembles a small flag or ensign.

The adult wasps do not normally attract attention because they are small, dark colored insects, which resemble somewhat an ordinary house fly when casually observed. To a person familiar with insects they are readily recognizable, because of the long hind legs and the small modified abdomen. When the proper environmental conditions are present, and there is an abundance of cockroaches, certain species of these wasps will increase greatly in numbers, and may become pests.

It was interesting to the writer, that for a period of several months during 1951, a family living in Worthington, Ohio, complained a great deal about the evaniid wasps which they would find in the windows and other areas of their home. The wasps annoyed them by their presence, but they did not seem to mind the Oriental roaches which could be found in abundance in the basement of their home. On another occasion in a barber shop in Columbus, Ohio, the barber was observed by Dr. D. M. DeLong of The Ohio State University, using a fly swatter to kill what he considered to be flies. These insects were identified by Dr. DeLong as Evaniidae which were parasitizing the roaches in the basement underneath the shop, and actually aiding in the control of these pests.

The annoyance of these wasps is due mostly to their habits as adults, because during this period of their life cycle, they are very active and move about a great deal by walking and flying short distances. This activity is carried on in the daytime as well as at night, and for this reason they are often noticed when their hosts are not. The annoyance caused by these wasps is due to a dislike of insects rather than any harm that is actually done, because the parasites, as far as is known, do not bite or sting.

The Evaniidae can be classified biologically into two groups, those that parasitize the egg capsules of domestic roaches, and those that attack the egg capsules of wood-roaches. Two species of Evaniidae are known to attack domestic roaches in the United States, these are *Prosevania punctata* (Brullé) and *Evania appendigaster* (Linn.). Both of these species are believed to have been introduced into this country along with their hosts. There are in addition, several species of Evaniidae that are native to the Nearctic region, and data from available rearing records show them to be parasitic in the egg capsules of our native species of wood-roaches.

Prosevania punctata (Brullé) is the most common evaniid found in Ohio, it has been found by the writer in abundance in several buildings. When the roaches were cleared from these buildings the wasps also disappeared. This is due of course to the elimination of the host, and because the new organic insecticides which are now in use seem to be just as effective in killing the parasites as they are in killing the host. These parasites are especially vulnerable because they walk

about a great deal in the areas of the home which are normally sprayed in roach control. It will be interesting to observe what effect the new insecticides will have on the future abundance of these parasites. When a building which was known to contain evaniids was sprayed with 0.5 percent chlordane solution, a survey was made of the premises daily for several days afterwards, during this time several dead wasps were found, along with numerous Oriental cockroaches. As no dead wasps had been found previously, the death of the parasites was probably due to the insecticide.

Adult Oriental and American cockroaches deposit their egg capsules in corners or crevices, and it is usually some days before the nymphal roaches emerge from them. It is during this period of egg incubation, after the capsules are deposited, that the adult evaniid wasp seeks out and parasitizes them. The female *Prosevania punctata* deposits a single egg inside the cockroach egg capsule by inserting her ovipositor through the hard outer covering. All of the immature stages of the wasp are then spent inside of the cockroach egg capsule, and the adult emerges completely developed. There are usually from three to four generations of *Prosevania punctata* per year.

In studies of wood-roach egg capsules collected under natural conditions in the field during 1951, it was found that evaniids of the genus *Hyptia* were parasitizing as high as 6.7 percent of the capsules of our native species of roaches. *Hyptia thoracia* Blanchard, was found to overwinter inside of the egg capsule as larvae and this species appear to have a single generation per year.

Examinations made of egg capsules after the adult evaniid wasps have emerged demonstrates a similarity in appearance and the result of parasitism. The entire contents of the egg capsule are consumed during the period of larval feeding. Each evaniid larva thus destroys anywhere from 8 to 40 potential roaches, according to the species parasitized.

The evaniid adults differ markedly from the larvae in their choice of food. As has previously been stated the larvae act as egg predators in the cockroach egg capsule, while the adults have been observed feeding on flowers. Some adult *Prosevania* have been kept alive in the laboratory cultures for approximately 20 days by feeding them on 5 percent honey water. As far as is known, no attempt has been made to utilize these parasites as biological control agents for roaches.

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MICROBIOLOGICAL STUDY OF ACID MINE WATERS: PRELIMINARY REPORT

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Waters issuing from bituminous mines may be either acid or alkaline. The acid mine waters are objectionable; their disposal or abatement is highly desirable. Many agencies are concerned in the reduction of this important industrial waste for several reasons: pollution with acid wastes renders streams extremely acidic, pH 2.0 to pH 4.0, which results in the annihilation of the majority of commonly encountered micro- and macroorganisms in water; high concentrations of ferric, ferrous, and sulfate compounds are hazardous to children using such streams as bathing areas; the aesthetic quality of these streams is in a deplorable condition due to the deposition of ferric hydroxide in the channels of the streams.

FORMATION OF ACID MINE WATER

The oxidation of sulfur and sulfur-bearing compounds in coal seams results in the formation of large quantities of acid compounds available for solution in water. It is assumed that ferric disulfide is oxidized to soluble ferrous sulfate and sulfuric acid:

$$2FeS_2 + 7O_2 + 2H_2O \longrightarrow 2FeSO_4. \quad (1)$$

When these acid wastes enter streams they are exposed to atmospheric conditions and atmospheric oxidation of ferrous sulfate to ferric sulfate and water occurs:

$$4FeSO_4 + 2H_2SO_4 + O_2 \longrightarrow 2Fe_2(SO_4)_3 + 2H_2O. \quad (2)$$

The subsequent hydrolysis of ferric sulfate yields ferric hydroxide:

$$Fe_2(SO_4)_3 + 6H_2O \longrightarrow 2Fe(OH)_3 + 3H_2SO_4. \quad (3)$$

Ferric hydroxide in conjunction with hydrated iron oxides is precipitated in the stream's course to impart a rusty color.

Carpenter and Herndon (1933) and Hodges (1938) have reported analyses of this type of drainage which vary widely from one stream to another. The analysis of a stream gave the following results; pH 2.0; total acidity, 47,800 ppm; sulfates, 41,700 ppm; total iron, 12,270 ppm. The author has reported the following variations for streams having a pH range from 2.0 to 2.9: total acidity, 196–106,000 ppm; total residues, 7,700–40,000 ppm; calcium, 145–300 ppm; magnesium, 20–55 ppm; sulfate, 100–18,300 ppm; ferric iron, 30–3,900 ppm; and ferrous iron, 20–1,200 ppm.

Numerous attempts have been made to abate or modify acid drainage issuing into many streams. Sealing of abandoned mines has been instituted to reduce the oxygen concentration with the hope that less oxidation of sulfur compounds will ensue, resulting in a smaller amount of available acid compounds for solution in water. Chemical treatment to modify or rid water of objectionable compounds has been studied. Since such treatment is expensive and results in the accumulation of large amounts of sludge, it is not feasible.

Colmer and Henkle (1947) have approached the problem from a micro-biological point of view. They maintain that microorganisms are in part responsible for the formation of large quantities of sulfuric acid and ferric hydroxide. Therefore, studies were undertaken to determine the role of microorganisms in the formation of acid mine waters. They were able to isolate two significant organisms; one was an unidentified bacterium involved in the oxidation of ferrous sulfate to ferric sulfate, and the other was *Thiobacillus thiooxidans* which is capable of oxidizing sulfur compounds to sulfuric acid. It is suggested that the study of the relationship

of microorganisms to the formation of sulfuric acid might provide a more effective method for the abatement of objectionable acid wastes.

Since conditions of extreme acidity and hyperconcentration of iron compounds provide a profound adverse environment for the survival of a great majority of micro- and macroorganisms indigenous to streams, the author has instituted the investigation of the diversity of genera and species tolerating such conditions.

In an attempt to review the literature pertaining to the microbiological assay of acid mine waters it becomes apparent that such information is entirely lacking. A few theses and articles of many kinds were examined, but data pertinent to the author's work are not accessible.

These studies were first begun to determine the viability of *Escherichia coli*, the organism used as the index of fecal pollution, in acid mine streams, but were later merged into a study of all viable microbes. The task at hand was to isolate, cultivate, observe, and attempt identification of the various kinds of organisms capable of tolerating conditions existing in acid waters and to observe the direct or indirect effects of acid waters upon the existing microorganisms. A preliminary study was also made for the special groups, i.e., colon-typhoid, sulfur bacteria, iron bacteria, actinomycetes, and fungi.

MATERIALS AND METHODS

Microflora. Samples were collected from acid streams in northern West Virginia and Pennsylvania in previously sterilized (autoclaved) sampling bottles by submerging the mouths of the bottles against the current of the stream (most aseptical method), and filled to capacity to eliminate any air space. The presence of sufficient oxygen would result in the oxidation of ferric sulfate to ferric hydroxide and sulfuric acid. Analyses of all samples were made as soon as possible after collection.

The above water samples were plated on various agars suspected of supporting the growth of a few or a single organism. Various types of broth combinations were inoculated with aliquots of mine water. Streaks were made for these broth tubes onto agar in an attempt to procure pure cultures of the growing organisms. Pure cultures were numbered and transferred to fresh media at intervals in order to maintain identity and viability. The preparation of suitable media proved to be the most difficult task.

In order to isolate special group organisms, elective cultural methods were employed. All waters were inoculated into the synthetic medium of Waksman and Starkey (1922) for the cultivation of sulfur bacteria, artifical mine water medium for the cultivation of iron bacteria, peptone malt agar for fungi, and potato glycerol agar for actinomyces.

Diatom study. In collecting samples of diatoms, pyrex resistant glass was used in order to reduce the deteriorating effects induced by the absorption of alkali from ordinary glass. On each trip to the mine streams definitely marked spots were examined continually so as to thoroughly study the algae present. Subsequently, various other areas were picked and thoroughly studied. After a great number of samples were collected from numerous areas, no cross-sectional data of the diatom flora were obtained. Precise notes were taken as to the time of sampling, the place and the exact spot so that in case further study is necessitated one may return to the exact location for sampling. All of the above data were placed on each sampling bottle, and if worthy of preservation, it was recorded in a record book. Samples were taken by the removal of surface mud and scraping from rocks and twigs on the stream bed.

Of great importance is the immediate examination of samples, since algae tend to deteriorate rapidly. If samples were to be stored for any length of time, special methods of preservation were employed, namely, fixation with King's fluid, picro-sulfuric acid, or osmic acid. One of the best methods for the study of living

diatoms is by the hanging drop mount preparation. Motility and similar functions performed by delicate structures are very difficult to preserve, thus, immediate observation is recommended and almost indispensable.

The internal structure of diatoms was not considered in their identification. However, the ornamental sculpturing of their cell wall, their shape, and their size were utilized to accurately determine genus and species names.

The method employed for elucidating cell wall sculpturing was the siliceous corrosion method. This procedure may be outlined briefly. Treat the material containing diatoms with concentrated HCl until effervescence ceases. Allow material to remain in HCl for two days to remove any debris adhering to the diatoms, and then filter through coarse muslin. Centrifuge the filtrate and wash the remaining precipitate several times with water. The washed precipitate is treated with concentrated H_2SO_4 and a small crystal of $K_2Cr_2O_7$ to char or dissolve any organic material present. Repeat the H_2SO_4 -bichromate treatment several times. When the diatoms are scrupulously cleaned, they are infiltrated with canada balsam and mounted on microscope slides. The slides thus prepared are used for taxonomic study.

Microfauna. Isolation and identification of the organisms comprising the microfauna were based entirely upon the microscopic study of cellular morphology. Various water samples, atrocious surface deposits, and surface soils were collected and examined. Cultivation of this group was not attempted, since microscopic observation proved sufficient for identification. Seasonal examinations were made in order to account for any possible variation of the microfauna with the season.

RESULTS AND DISCUSSION

Microflora

Bacteria. By the exploitation of every method for isolation, either original or duplicated, 40 species of bacteria were obtained in pure cultures. Of the 40 species, 14 were gram positive, spore-forming rods belonging to the genus *Bacillus*, 2 were gram-negative rods belonging to the genera *Escherichia* and *Aerobacter*, and 20 were gram-positive cocci belonging to the genera *Micrococcus* and *Sarcina*. The remaining species were members of the genera *Thiobacillus*, *Crenothrix*, and *Microsporium*.

Colmer and Henkle (1947) have reported frequent isolations of *Thiobacillus thiooxidans* from acid mine streams which provide confirmative evidence. Ellison (1919) reported the isolation of *Microsporium desulphuricans* and *Vibrio desulphuricans* from surface mud in acid mine water.

Table 1 illustrates very clearly the presence of bacteria in a paucity of numbers in acid mine streams, and table 3 shows that the members are equally divided between the genera *Bacillus* and *Micrococcus*.

Fungi. It is interesting to note that fungi are not as well represented as one would anticipate in view of the existing acid conditions conducive to their growth. Organisms of the genera *Aspergillus*, *Helminthosporium*, *Penicillium*, *Trichoderma*, *Cladosporium*, *Alternaria*, and *Trichothecium* were isolated and identified. The relative quantitative plate counts for fungi and bacteria may be seen in table 1.

Actinomyces. Members of the genus *Actinomyces* were not isolated directly from acid mine streams, but the examination of soils moistened with mine water seepage showed their presence.

Diatoms. Thorough investigation of the abominable brownish and greenish-brown deposits on the stream beds revealed the presence of myriads of diatoms having an almost ubiquitous distribution. *Navicula viridis* appeared to be the only existing form, but by very meticulous and effectual methods many other genera and species were identified. The multitude of diatoms in every acid mine stream examined has led the author to suggest that these organisms may be

used as an index of acidity. A total of 8 genera and 18 species of the class Bacillarieae have been characterized, and are recorded in table 2. It is beyond doubt that diatoms are the most abundant forms of life to be found in acid mine streams.

TABLE 1

Quantitative plate counts for acid mine streams and soils along their banks.

Stream	pH	Bacterial Count per ml	Fungal Count per ml	Actinomyces Count per gm of soil
A	2.0	4,800	90,000	3,600
B	2.4	18,000	60,000	6,400
C	2.5	39,000	120,000	13,000
D	2.8	24,000	118,000	7,000
E	3.0	180,000	160,000	13,000
F	3.15	150,000	190,000	21,000
G	3.3	83,000	180,000	7,500
H	3.9	470,000	110,000	16,000
I	4.0	560,000	590,000	26,000
J	4.0	340,000	640,000	18,000

TABLE 2

Diatoms isolated from acid mine streams which have been identified.

1. Navicula viridis	7. Surirella biseriata	13. Cocconeis placentula
2. Navicula lanceolata	8. Surirella saxonica	14. Cocconeis pediculus
3. Navicula oblonga	9. Denticula spp.	15. Cocconeis spp.
4. Navicula spp.	10. Nitzschia sigmoidea	16. Synedra ulna
5. Navicula spp.	11. Homoeocladia vermicularis	17. Meridion circulare
6. Navicula spp.	12. Homoeocladia spp.	18. Rhoiosphenia curvata

TABLE 3

Microorganisms isolated from acid mine waters.

BACTERIA:		
	Bacillus subtilis	*M. pyogenes* var. *aureus*
	Bacillus spp.	*M. varians*
	B. lentus	*M. desulphuricans*
	B. cereus	*Escherichia coli*
	B. mycoides	*Aerobacter aerogenes*
	Micrococcus spp.	*Thiobacillus thioparus*
	M. pyrogenes var. *albus*	*T. thiooxidans*
		Crenothrix polyspora
FUNGI:		
	Aspergillus sp.	*Alternaria* sp.
	Trichoderma sp.	*Penicillium* sp.
	Helminthosporium sp.	*Trichothecium* sp.
		Cladosporium sp.
ACTINOMYCES:		
	Several unidentified species	
DIATOMS:	(see table 2)	
PROTOZOA:		
	Amoeba proteus	*E. mutabilis*
	Euglena viridis	*Paramecium caudatum*
TROCHELMINTHES:		
	Rotifers	

Microfauna

Animal life fares no better in these acid streams, since only the phyla Protozoa and Trochelminthes were identified.

Protozoa were represented by *Euglena viridis* and *Euglena mutabilis* of the

class Mastigophora, by *Paramecium* of the class Ciliata, and by *Amoeba* of the class Sarcodina. *Euglena viridis* is *per se* as abundant as the entire group of diatoms, for they are very acid-tolerant organisms. Trochelminthes were found very sparingly and only as rotifers. Lackey (1938) has reported the existence of rotifers, ciliates, and flagellates in acid waters which provides a corollary to these observations.

In passing it might be mentioned that higher animal and plant forms than those reported here are not to be found in acid mine waters, save a few plant forms. Thus, one can readily see that these waters constitute a very objectionable class. Even though conditions in acid mine streams appear highly adverse for the viability of microorganisms, Joseph (1951) has shown by means of longevity studies and actual isolation of *Escherichia coli* that the transmission of disease is still possible.

SUMMARY

The most highly acid streams will support the growth of a few microscopic organisms.

Bacteria are represented by the genera *Bacillus*, *Micrococcus*, *Sarcina*, *Escherichia*, *Aerobacter*, *Thiobacillus*, *Crenothrix*, and *Microsporium*. The bacteria are almost equally divided among the genera *Bacillus* and *Micrococcus*, but their abundance relative to their numbers in alkaline waters indicates an intensive detrimental effect of acid mine water. This is also borne out by the fact that variant or aberrant forms of the surviving organisms are frequently encountered. *Escherichia coli* is capable of surviving acid mine waters, therefore, its tolerance is indicative of the ability of the typhoid bacillus to also be tolerant and probably present.

Fungi are relatively abundant and are represented by seven genera. Quantitative plate counts for fungi range from 60,000 to 640,000 per ml, but these count are much lower than one would anticipate. It is also interesting to note that Actinomyces were not isolated from acid mine waters, but were present in the soil along the banks of the streams. Quantitative plate counts for Actinomyces range from 3,600 to 26,000 per gram of soil.

Diatoms are very abundant in acid mine streams, and are represented primarily by *Navicula viridis*. The author suggests the use of this organism as an index of acid conditions, since little skill is required for its recognition. A total of 8 genera and 18 species of diatoms have been isolated from various acid streams and identified.

There is a great reduction in the microfauna of acid mine waters, since they are shy of every phylum, except for a few members of the phyla *Protozoa* and *Trochelminthes*. Protozoa are represented by *Euglena viridis*, *Euglena mutabilis*, *Amoeba*, and *Paramecia*. *Euglena viridis* is the most abundant organism, and its association with acid waters indicates its use as an index for acidity. *Trochelminthes* are represented only by one member, rotifers.

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